INDUSTRIAL TRAINING RESEARCH PROJECT

R.A. SWANSON
S.A. SAWZIN

BOWLING GREEN STATE UNIVERSITY
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Abstract

The purpose of this study was to conduct an experimental comparison of the structured versus unstructured training of semi-skilled production workers.

The experiment was implemented using the following procedures: a production job representative of those semi-skilled jobs in the Johns-Manville Corporation was selected; the two training programs for the representative production job were characterized and developed; production trainees that represented a production worker profile were selected and hired; evaluation methods for product quality, worker competence, cost effectiveness, and worker attitudes were developed; and the experiment was executed comparing the two training programs.

The data provided several conclusions. Structured training time was significantly less than unstructured to produce competent workers. The structured training group achieved significantly higher levels of production worker competence by time intervals. The total development and training costs were not significantly different. The production losses were significantly higher in the unstructured training program. Subjects in the structured training program solved a higher percentage of production problems. There was no significant difference in the attitudes of the trainees of the two groups towards their training.

ACKNOWLEDGEMENT

While the majority of the excitement and headaches resulting from the Industrial Training Research Project have been absorbed by us, it is fitting to note that this work would not exist without having had the support of two institutions and many people.

With equivalent but different contributions, this research was directly supported by Johns-Manville Corporation and Bowling Green State University. The services of J. G. Cullen and Gary Sisson from Johns-Manville Corporation, along with Professors Richard Kruppa, Anthony Palumbo and George Scherff from Bowling Green State University, were instrumental in the conduct of the research. The cooperative secretarial and operational support from Ellen Bechstein made many of the unrealistic deadlines possible.

We think it was worth it!

Richard A. Swanson, Director

Stephen A. Sawzin, Research Assistant

Industrial Training Research Project

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CHAPTER I

INTRODUCTION

Industrial training can theoretically be divided into two forms: structured and unstructured. Structured training can be thought of as the training of a new worker through a systematically developed educational program. On the other hand, unstructured training is on-the-job training of a new worker by an experienced worker who simultaneously continues to perform his regular duties.

While the merits of structured industrial training are widely presented in the literature, little if any controlled research is reported (Antil, 1972, p. 17). This literature is obviously being written by advocates of structured training programs. When confronted with management opposition, the lack of empirical research leaves those interested in training only with the power of persuasion. Opposition to training is a result of economics. As the profits of a company go, so goes training (Douthat, 1970, p. 4). Industrial training is often considered an overhead "frill" by production management. As a result, training is often the first department to have funds cut in a tight economic atmosphere (Douthat, 1970, p. 4).

The power of persuasion and management dictates should not be the criteria by which industrial training investments are made. Whether or not training is a "frill" or a needed production tool can only be assessed if the relative production time, worker attitudes, and cost effectiveness are known.

Purpose of the Study

The purpose of this study was to conduct an experimental comparison of the structured versus unstructured training of semi-skilled production workers.

Sub-Problems

1. To select a production job representative of those semi-skilled jobs in the Johns-Manville Corporation (J-M).
2. To characterize and develop an unstructured training program for the selected production job that is representative of the Johns-Manville unstructured training practice.
3. To characterize and develop a structured training program for the selected production job that is representative of the Johns-Manville structured training practice.
4. To select trainees that are representative of a Johns-Manville production worker profile.
5. To develop methods for evaluating the product quality, worker competence, cost effectiveness, and worker attitudes.
6. To execute the training experiment and collect the data.
7. To analyze the data by making the following comparisons to evaluate the effectiveness of the two training methods:

    A. training time required of the unstructured training program as compared to training time required of the structured training program to produce competent production workers.

    B. a comparison of levels of production worker competence by time intervals between structured and unstructured training.

    C. the total development and training costs of the structured training program as compared to the development and training costs of the unstructured training program.

D. the production losses of the structured training program versus the unstructured training program.

E. the reactions of the structured training program operators to production problems (malfunction performance test) versus the unstructured training program operators.

F. the attitudes of the trainees in the structured program towards their training, trainer and job versus those in the unstructured program.

Significance of the Problem

Empirical data on the effectiveness of unstructured and structured industrial training, while not available, is necessary to make intelligent decisions concerning training. The capital investment in training is too great and the potential return too important to allow decisions of training policies and practice to be based solely on powers of persuasion and the immediate economic state (Burke, 1969, p. 24).

This research will be the first step in providing such information. The fact that corporate level production and training personnel of Johns-Manville have spent considerable time articulating the need for such information and now are providing financial support for this Industrial Training Research Project (ITRP) is further evidence of the significance of this research.

Limitations of the Study

This study is limited by the representative job, production worker profile, structured training characteristics, and unstructured training characteristics that have been specified for this research.

Definition of Terms

Structured training: When a thorough job analysis is used as a basis for self-instructional and/or instructor based instruction program that has been systematically developed to train a new worker in a logical progression from zero job competency to a specified mastery of the job. The trainee is the focal point of the training effort.

Unstructured training: No purposeful instructional plan is used to train a new worker. The training is not systematic and the worker is usually trained by an existing employee (worker-trainer) while on the job. The worker-trainer has little or no interest in training, minimal to mastery of the job procedures, and little to no instructional skill. The on-going production output is the focal point of the worker-trainer instead of the training experience of the trainee.

CHAPTER II

REVIEW OF THE LITERATURE

Need for Specific Training

The specific uses of job training by industry are to train a newly employed worker, to transfer the existing employee to another position, to promote a worker, to produce and service a new product, to initiate a new manufacturing procedure, or to increase safety (Evans, 1971, p. 207).

A 1963 survey indicated that most adult workers learned their job skills through informal on-the-job training or had just picked up the necessary skills needed while working (Task Force, 1968, p. 35). Workers have also changed jobs approximately nine times during their working lifetime, of which the majority also changed occupation and the industry in which they worked (Evans, 1974, p. 24; Palmer, 1954, p. 5). As industry becomes more complex, job training will need to change to cope with both voids in training and the need for retraining (Froomkin, 1958, p. 485; Burke, 1969, p. 24).

Actual manpower needs of this society have been dramatically over and under estimated. Occupational shifts in adults have forced them to cope to changes within their career (Lippit, 1969, p. 8). Because the educational institutions have not been aware of technological changes and job skill shortages, there has been a lack of trained and educated individuals from the formal schools to meet the real industrial job skill needs (Evans, 1971, pp. 10, 14, 22). Labor Assistant Secretary

Jerome M. Roson indicated that there will be an expected increase of 100 million workers into the nation's labor force by 1980 (Training and Development Journal, 1970, p. 11).

The economics of industry also point to a need for job training. Because of high competition in the products and services market, a better trained worker can adjust to changing job trends (Lippit, 1969, p. 8). Management cannot expect production efficiency from untrained or poorly trained personnel assigned to operate expensive and sophisticated equipment (Wenig & Wolansky, 1972, p. 3). Unlike public industrial education, company run training involves just those skills and knowledges that are unique to a particular job situation (Evans, 1971, p. 10). An argument against sophisticated training is that one can expect that with increased automation in industry, the need for a trained worker "skill" is not as badly needed (Froomkin, 1968, p. 485). While the breadth of knowledge and experience of the skilled worker is becoming narrower, the high level of skill remains important in most production jobs. Overall, this argument depends largely on the amount of automation involved in the production operation. As the trade or production manufacturing becomes more sophisticated, training and revision of existing training programs will continually be needed (Stutt, 1972, p. 42). Management has been modifying its attitude about training during the past decade and is more willing to think of training as being economically sound (Odiorne, 1970, p. 14; McKee, 1969, p. 27).

Nature of Structured and Unstructured Training

Part of the historical development of job training in industry and its rise to influence was due to the addition of training and development departments to industrial firms (Wenig & Wolansky, 1972, p. 5). These training professionls have indicated through various writings the need for structured job training (Barber, 1969). An example is a study showing the advantages of structured orientation of new employees. This orientation program resulted in reduced worker anxiety and increased productivity (Mahoney, 1969, p. 23; Gomersall & Myers, 1966, p. 62). A structured training program for production workers in a new plant start-up resulted in three important factors (Sisson, 1972, p. 22):

1. An orderly start-up of new plant facilities with increased production.

2. No personal safety accidents.

3. Increased cost-effectiveness of the 1972 training program versus the 1963 training methods.

The heart of the structured approach is the logical analysis of all aspects of training. It tries to consider not only the obvious, but also to notice and weight the seemingly minor points needed to develop a fully trained employee. This consideration is shown in a study of the training of clerical workers through the use of programmed audio - visual instruction. The study resulted in greater retention by the learner, individualized instruction to meet trainee's needs, and lower training costs (Krag, 1970, p. 36).

A relatively large portion of the initial employment of a new worker is spent on training. If this training is structured with stated objectives of worker performance, it will give the worker specific insight in his employment responsibilities (Seymour, 1968, pp. 2, 14). The worker can be trained in a shorter time with reduced training and production costs. Retraining existing employees also becomes easier (Seymour, 1968, p. 14).

Unstructured training is an unsystematic effort at training. While the general goals of preparing an efficient new worker may be the same as with a structured program, the difference is that there is no analysis of the job, no controlled training, or sequential development and evaluation of the worker at any point in his training. The new worker is brought into his new job and usually picks up his training through the "osmosis" of information from a fellow worker who is experienced in the job procedures (Wenig & Wolansky, 1972, p. 22). This type of training has been called the "buddy-system" of training (Barber, 1969, p. 82) or "unstructured training" (Cullen, 1973).

The major case for unstructured training is presented by production managers. Their reasoning is that of economics. A structured training investment (cost) is not needed since the worker will be trained by an experienced worker on the production line. The worker doing the training is already being paid and the trainee is working and learning under him (Cullen, 1973).

Economics of Training

The controversy over structured versus unstructured training is perpetuated by inadequate research on their economic advantages. Training costs, however the methods, are an economic burden which is paid out of the company's profit or overhead (Wheeler, 1969, p. 14) with two questions being asked, "What does it cost if we do it (train)"? and "What does it cost if we don't do it"?. Sophisticated cost analysis and management is needed to resolve the financial management of the training program (Wheeler, 1969, p. 18).

A newly trained employee quitting his job and taking his training to a new job with better economic advantages for him is another economic reason for resisting or minimizing training. This situation is equally prevalent in large and small firms, though the smaller firm is at a greater economic disadvantage (Frankel, 1969, p. 28).

The calculation of training costs is diversified. There is no single formula. A narrow formula might be to use conventional accounting of fixed, variable, and total costs (Wheeler, 1969, p. 18). This is one simple method that can be used in cost prediction or overall cost analysis. A cost-effectiveness model developed for this study is found in Appendix A.

It may be that extensive cost analysis discussions result in few company-supported training efforts. Hard economic questions asked at the onset may scare off training programs (Furst, 1970, p. 30). Instead of initial comparisons of costs, one could envision training in terms of an investment, and return on investment (Furst, 1970, p. 30). Unlike an investment, training and development is often treated as a luxury of a firm. Several other situations work against the investment concept. Managers are rewarded for profits on an ongoing basis and are reluctant to hire and train for the future. Transferring of employees is often restricted because departments are reluctant to give up employees whose training costs have been charged to their budgets (Douthat, 1970, p. 36).

Evaluating Training

Training evaluation can be divided into three main areas. First, the cost of training can be stated in a ratio of production output versus amount of training time or training time as compared to time expended to reach competency. Secondly, the cost of training can be stated as a relationship of the training program and expected worker behavior. The third training evaluation, and the hardest to evaluate, is the separation of on-the-job production behavior versus training behavior. How does one separate on-the-job production profit and production time for the company from training time and training costs when it appears that the trainee is simultaneously performing as trainee and worker?

Evaluation can be conducted using basic accounting measures in calculating fixed, variable, and total costs involved in training. The time and training methods of various aspects of training can be given a dollar value and added to determine a total training cost (Wheeler, 1969, p. 14).

Interpreting training costs over time allows training to be calculated as an investment along with the returns from that investment. This method studies the total costs versus the maximum training time and compares them to the time a trainee stays with a company thus lowering the costs with each progressive year he produces for the company (Furst, 1970, p. 30).

Evaluation of training can be independent of the costs. One method is determining all the phases of training and evaluating each phase through different evaluation procedures. This type of evaluation determines how well the training conducted meets the objectives of the training program (Rose, 1968, p. 38).

Job loss by individuals may be more of a function of job-related attitudes rather than a deficiency in technical skill. The training and evaluation should then heavily concentrate on beneficial job behavior traits with a rating scale as to the importance of behavior traits to the job (Buehler, 1969, p. 16).

Developing Structured Training Programs

Structured training programs may take as many shapes as those who develop them. One is the use of systems engineering techniques as applied to training (Silvern, 1972, p. 4). This method incorporates the use of the computer and systems engineering applications to analyze, synthesize, and simulate job requirements into a training program. This system has reduced the time taken to attain an experienced worker standard by one-third of that previously known.

A study done for the United States Air Force resulted in a matrix to identify the components of training and their importance into levels of high, medium, and low. This method used weight scales to determine the effectiveness of training by determining if the training given was important and how much time should be given to train a particular concept (Kayloe, 1971, p. 21).

One basic training system is the Job Instruction Training System (Ford, 1970, p. 29). This system uses a four-step approach; preparing the learner, present the material, have the learner apply the learning, and test for understanding. These basic four steps can be expanded for a more complex training system (Ford, 1970, p. 29). These systems, and others developed in industrial training departments for specific use, have certain similar components that are listed below:

1. Job Analysis
2. Task Analysis
3. Target Population
4. Course (training) Objectives
5. Course (training) Procedures
6. Measuring Instruments
7. Types of Performance
8. Selection of Instructional Procedures
9. Sequencing Instruction Unit

(Mager & Beach, 1967)

Summary

In theory, a structured training program has the advantage over unstructured training in that it can develop a better-trained worker with positive feedback on trainee development and training costs. At surface evaluation, unstructured training is inexpensive, effective, and easy to implement. There is little or no evidence to prove or disprove these statements. Until training methods are submitted to systematic and carefully controlled research and evaluation, management will continue to use or discard a tool (structured or unstructured training) of unknown value (Burke, 1969, p. 24).

CHAPTER III

PROCEDURES

The organization of this "procedures" chapter was based on the sub-problems of the study that were presented in Chapter I. Their abbreviated topics are as follows:

1. Selecting a representative job
2. Characteristics of the unstructured and structured training programs
3. Development of the unstructured training program
4. Development of the structured training program
5. Selecting trainees
6. Data collection methods and instruments
7. Execution of the experiment
8. Analysis of the data

Selecting a Representative Job

The selection of a representative production job of the J-M Corporation required logical rather than statistical procedures. A series of tentative decisions, review sessions, adjustments and a final decision was the overall strategy.

Specifically, the Industrial Training Research Project (ITRP) director met with the J-M training personnel at the Bowling Green State University (BGSU). They discussed their perceptions and observed the industrial processes available in the BGSU Manufacturing Laboratory. The tentative choice was to use the Rainville Plastics Extruder (Appendix B) because of its face validity to J-M operations and general difficulty of operation.

The research assistant then operationalized the Rainville Plastics Extruder and became more familiar with the process. After this, the project director met with both the J-M corporate and division level training personnel and production managers. Their review and approval of the pipe extrusion operator's job was the next important step in insuring its appropriateness to J-M semi-skilled industrial production operations.

A pipe extruder operator job analysis was then made (Appendix C) before the final approval was given by both J-M and ITRP staff.

In conclusion, it was determined that the plastic pipe extrusion activities had a sufficient number of variables to make the tasks of a difficulty proportional to J-M pipe extrusion operations and to many other semi-skilled production jobs. Basically, the job involved the extruding of quality plastic pipe from a plastic extrusion machine. To facilitate this, the following items were utilized in the job setting:

1. Plastic raw material
2. Plastic extruder
3. Vacuum pump
4. Work bench
5. Cut-off saw
6. Tool box
7. Hand tools (plyers, tin snips, knife)
8. Plastic regrind machine
9. Regrind storage bin
10. Pipe dimensional test device
11. Plastic raw material storage bin
12. Utilities (electricity, water)
13. Bench stools
14. On-the-job pipe storage
15. On-the-job scrap storage

The physical layout and photograph of the above facilities is shown in Appendix D.

Characteristics of Unstructured and Structured Training Programs

Early in the Industrial Training Research Project (ITRP), attention was directed at defining the dimensions of and differences between J-M structured and unstructured programs. The following discussion is an overview of those efforts.

Inherent in the word "unstructured" is a looseness of definition or specificity. While unstructured training within J-M operations does allow for a wide range of training variables, there are many common conditions and variables that can characterize J-M unstructured training programs. The attempts were to identify and simulate those conditions and variables for this research. Of equal concern was the identification of those conditions and variables that surrounded standard J-M structured training practice. In both cases the reader may find them equally applicable to other training settings.

The process of identifying conditions and variables that surround J-M unstructured and structured training was as follows:

1. The ITRP director met with selected J-M corporate and training level staff to discuss perceptions and opinions.

2. The ITRP director solidified the results of the above session along with library research into a rough draft of specific characteristics.

3. The rough draft was reviewed by the total ITRP staff and with J-M corporate training and production personnel.

4. The reactions were summarized into ITRP "Working Paper Number One: Characteristics of Structured and Unstructured Training Programs" (Appendix E). The working paper provided a fundamental reference point in the development and execution of both the unstructured and structured training program.

Development of the Structured Training Program

There were six major steps in the development of the extruder operator structured training program. These steps were as follows:

1. Job analysis
2. General training design decisions
3. Specific training design decisions

4. Produce the training program
5. Pilot test the training program
6. Finalize the training program

The job analysis was done by the ITRP director and research assistant after the research assistant had become totally familiar with the operation and pecularities of the plastic extrusion machine. The plastic extruder operator job analysis contains a job description, job tasks, and task detailing sheets and may be found in Appendix C.

The detailed job observation and analysis provided the information base to first make the general and then the specific training design decisions (Appendix G). The training design decisions are evidenced in the completed trainer's (Appendix H) and trainee's manuals (Appendix I). The pilot testing, revision and finalizing process were important steps to the finalized training program. Organization of the work station, labeling of containers and measurement points were additional outcomes of the structured training program development.

Selecting Trainees

The selection of experimental subjects (trainees) typical of a J-M semi-skilled job trainee was based on logical rather than statistical procedures. To develop a worker profile a series of tentative decisions, review sessions, adjustments, and a final development was conducted.

J-M Corporation, as a result of having many small and large manufacturing plants that are largely in low density rural areas, has to endure a tight labor market (Klousing, 1973). The potential Johns-Manville employee is often determined by the seasonal calendar. The applicant may come from a farm background during the winter months, or a high school or college background during the summer months. The applicant's personal profile may depend a great deal on the geographical region in which he lives and the availability of educational and occupational opportunities (Klousing, 1973).

The ITRP staff reviewed the profile of the average semi-skilled worker in the Ohio Wood County area. The following dimensions were identified as being part of a trainee profile:

1. Age
2. Educational level
3. Local worker mobility
4. Worker motivations
5. Local and surrounding communities
6. Seasonal trends
7. Ramifications of local industry and BGSU

A worker profile was developed from this information and discussed with J-M corporate training management. This profile listed categories of available persons, and characteristics of individuals that J-M may employ. The profile (Appendix J) was used in the selection of subjects for the research.

Recruitment

The subjects were recruited from the methods listed below:

1. Employment agency
2. Newspaper advertisements
3. Advertising flier

The employment agency used was the Bowling Green office of the Ohio Employment Agency. The newspaper advertising was in the form of a want ad for part-time work. The advertising flier was a one-page sheet that was posted throughout the community and in local industries describing a position open for part-time work. Examples of these recruitment tools are found in Appendix K.

Response and selection

The subjects responded to the recruitment methods either by telephoning about the position or applying in person. The subjects were asked to complete an application form (Appendix L). This application form is slightly revised from those used by J-M. Upon completion of the application, the subject was asked to complete the Bennett Mechanical Comprehension Test (Appendix M). This pretest was used to obtain additional comparative data to determine the equality of the two experimental groups. A "t" test of means statistical comparison demonstrated that there was no significant difference ($p < .05$) between the pretest means of the two groups. This comparison, along with the no significant difference comparisons of the age and educational attainments between the two groups, assured their equality. Summary data on these three comparisons of means can be found in Appendix N.

During the application period, there was a short interview with the applicant to review and clarify the application. The applicant was told that the job entailed the operation of a plastic extruder and that they were being hired to operate the extruder to test its reliability. They were not told that their performance was being tested.

Applicants hired were scheduled to work around their personal time commitments. Forty (40) subjects were hired from approximately one hundred (100) serious applicants. There were twenty subjects in each group. It was impossible to hire the subjects as a group of forty and randomly divide them into two groups. There was an attempt to hire subjects consistent with the trainee profile for both experimental groups. Pretest scores were not used as a selection tool, but were used as an additional test of the equality of the two groups.

Data Collection Methods and Instruments

The fifth sub-problem presented in Chapter I of this study was to develop methods for evaluating the production product, time cost effectiveness and worker attitudes. Each of these evaluation tasks involved different criteria, methods, and instrumentation, and will be discussed separately.

Production product

Quantity and quality were considered in evaluating the production product. The quality of pipe production is based on visual and dimensional criteria. The visual criteria were handled in a judgmental format and are outlined in the Trainee's Manual (Appendix I). Samples of defective pipe became the comparative standard. The dimensional criteria of pipe roundness and concentricity required the development and validation of a test device. Such a device was developed and validated and is pictured in Appendix E. An extensive development and validation report on this instrument was prepared and available elsewhere (Sawzin, 1974).

The quantity of pipe production per fixed unit of time is a function of machine and worker capacities. Experience in equipment, materials, and the monitoring of on-going production is the basis for establishing a production quantity rate of pipe that meets qualitative standards. The minimum production quantity rate was set at fifty 3' lengths, or 2.50 pounds of 3/8 inch o.d. polypropylene pipe that meets specified quality characteristics.

Worker competence

Worker competence was defined as being able to start-up production, develop quality pipe, and to recover from two production problems (remotely manipulated machine variables) without a loss of production rate. Establishing a definition or criteria was much easier than the measurement of the actual attainment of competence.

Remote observation of worker performance was believed to be of fundamental importance. Direct observation would reveal a previously undisclosed interest in the trainee as well as cause Hawthorne Effect. A concealed closed-circuit television system was set up. The camera monitored the extruder operator work area and was broadcast to the ITRP office some 100 feet away.

The observational technique via the closed circuit television was the method for judging the "start-up" and "developing of pipe" criteria. Systematically measuring the trainee reactions to production problems was a complex task. It was felt that trainees should be exposed to the same production problems and that the problems should be at the control of the researcher. The difficulties were to identify the extruder machine variables, to develop a remote control for each of the variables (e.g., roller take-up speed), and to validate the reliability of the remote control device. Such a device and its reliability was developed (Appendix O). This device allowed the researcher to inject specific production problems at will and thus became the crucial method for establishing worker competence attainment.

Time

The problems associated with the recording of time were relatively simple. All production rates and observation logs were systematically time referrenced. Trainees bundled all product (quality and scrap) according to time intervals.

All trainees were observed via the concealed closed-circuit television system by the ITRP research assistant. A detailed hourly observational log was kept on each trainee.

Cost effectiveness

The cost inputs for the previously reported cost effectiveness model for the two industrial training methods were handled in a very practical manner. The actual expenditures from the ITRP budget were used. Simply stated; the hourly rate of the research assistant (who was performing as the industrial trainer) was used, as were the project costs for raw materials and so on. It should be pointed out that the cost calculations are extremely detailed, even to the point of costing out the paper upon which the job analysis was written.

It was obvious that every training situation will have varying personnel and material costs and that projections should and can be made for those particular situations.

Worker attitude

A Worker Attitude Inventory (Appendix P) was developed to assess the attitudes of trainees toward their training and job. The content validity was established through the development of questions around the following points:

1. Attitudes toward the job
2. Attitudes toward training
3. Attitudes toward the trainer
4. Attitudes toward the equipment

The equivalent form reliability coefficient of the attitude inventory was .86 for a sample of 20 subjects. The assumption is that with a larger sample an even higher and more accurate reliability would be reported.

Execution of the Experiment

The previous sections have detailed elements of the experiment. This portion will combine the elements into a complete profile of the experiment itself. When all provisions for the experiment were set-up and operable, the experiment was executed. The following research design provides an overview of the experiment:

Experimental Group 1- Unstructured Training Program: $M_1T_1M_2$
Experimental Group 2- Structured Training Program: $M_1T_2M_2$

M_1 = Bennett Mechanical Comprehension Test

T_1 = Plastic Extruder Operator Unstructured Training Program

T_2 = Plastic Extruder Operator Structured Training Program

M_2 = Plastic Extruder Operators' Performance Test and the Worker Attitude Inventory

In executing the experiment the unstructured training program was conducted first. A pilot program was utilized to test the organization and methods used to portray the unstructured training methods. Details of the unstructured training system have been previously discussed. During the experiment the research assistant played two roles. The first was that of the foreman. The second role was that of the researcher. The role of the researcher was the monitoring of the experiment (a closed circuit television camera was mounted in the rafters of the Technology Building Manufacturing Laboratory and cabled to a television monitor located in the ITRP office), the recording of the research data, arrangement of work schedules for the subjects, the recording of employment times and wages paid, and the testing of the trainee by the use of the remote control system. The research assistant was housed in the ITRP office located off the Manufacturing Laboratory (Appendix D).

In executing the unstructured training program it was necessary to schedule trainee work times in an overlapping arrangement and to schedule subjects in a linear progression since one subject must train another. The total time involved in executing the unstructured training group was dependent on the time necessary for a trainee to reach job competency and the work schedule of the subjects. Once trained, the trainee became the worker-trainer and was scheduled to train a new trainee. The tasks for the trainees to learn were the extrusion job procedures, to become proficient in the job tasks, and to train another subject on the job. When the subject completed being a trainee and worker-trainer, he was released from the experiment. The subjects were paid when released and asked to complete a posttest questionnaire.

The unstructured training program was completed when 20 subjects had been trainees and worker-trainers. During this time, work on the development of the structured training program was progressing. The structured training program was developed by the ITRP director and the research assistant. Representatives from J-M reviewed the program to assure its similarity to J-M training programs, procedures, and principles.

Subjects were advertised and hired for the structured training program based on the worker profile. The scheduling of the trainee was dependent only on their personal schedules. Training of the subjects was not dependent on the schedule of other subjects. The training of the subjects was not executed in a linear progression. Since an expected training time was practically pre-determined (Appendix G), as many as three subjects a day were scheduled independently.

In executing the structured training program the trainee was pre-tested, trained by structured training methods, and post-tested. A pilot test of the structured training program, training materials, and experiment organization was undertaken to determine the most effective use of the training materials and methods. During the pilot testing, J-M training personnel reviewed the implementation of the structured training methods. The trainees proceeded through the treatment (structured training program) as previously described. The research assistant performed the two roles of trainer and researcher. The researcher assistant monitored the experiment in the same manner utilized for the unstructured group. The major difference in the role was a change from the foreman to trainer characterization (Appendix Q). The researcher assistant's actions were dependent on the characterization of the roles.

The subjects were trained in both groups one at a time. The reason was because most new workers entering a J-M plant department enter on a worker turnover basis. It is reasonable to assume that in training groups, rather than individuals, that structured training would have an increased efficiency greater than unstructured training. The necessary adjustments needed for group instruction and their relative effectiveness is a subject for further research.

Data collection

During the experiment the necessary data was collected to answer the research hypotheses. The collection techniques and the data recording methods depended on the type of data needed. The recording of the training time was done by the research assistant. The times a trainee reported for work and ended work, the times a subject was a trainee, and the times a subject was a worker-trainer were recorded in a log.

The usage of raw materials was recorded for each hour even though this data was not used in the study. The extrusion process used in this study had little, if any, loss in material weight from raw material input to final product output. Therefore, only material output measurements were used.

To determine the efficient use of materials of one group to another, data was collected on production rates, production weight, and material waste (scrap). Production rate was recorded as the number of quality pieces of pipe extruded per hour of work. At the end of each hour the researcher collected and counted the production. The production was also weighed to determine the pounds of plastic used. The production count and weight was recorded in the log.

The plastic determined as scrap was collected, weighed, and recorded at the end of each hour by the researcher. Scrap was defined as plastic extruded not as pipe, and pipe not meeting the dimensional and visual standards. Comparisons were made between production weights and scrap weight per training group.

The attitudes of the subjects were recorded by a questionnaire completed by the subject at the end of the employment period.

The Program Evaluation Review Technique (PERT) was used to manage the ITRP. A PERT network, description of events, and a narrative of the operational procedures are contained in Appendix R.

Analysis of the Data

To evaluate the effectiveness of the two training methods, the following research hypotheses and statistical treatments were proposed in response to the sub-problems found in Chapter I.

Hypothesis I: Trainees receiving training by the structured method will achieve competency in significantly less ($p < .05$) time than those being trained by the unstructured method.

Hypothesis II: Trainees receiving training by the structured method will achieve significantly higher ($p < .05$) in job competence at the four hour, eight hour, and twelve hour time interval than those being trained by the unstructured method.

Hypothesis III: There will be no significant difference ($p > .05$) in the average costs to train twenty extruder operators by the structured method as compared to training twenty by the unstructured method.

Hypothesis IV: There will be no significant difference ($p > .05$) in the average production losses per trainee via the structured method as compared to those of the unstructured method.

Hypothesis V: Trainees receiving structured training will resolve significantly ($p < .05$) larger percentage of production problems than trainees receiving unstructured training.

Hypothesis VI: There will be no significant difference ($p < .05$) in attitudes toward the job and training among structured method trainees as compared to unstructured method trainees.

CHAPTER IV

PRESENTATION AND DISCUSSION OF THE DATA

The purpose of this chapter is to present and discuss data relative to the six hypotheses presented in the preceding chapter. The hypotheses will be restated with the supportive data presented and discussed.

Research Hypothesis I: Trainees receiving training by the structured method will achieve competency in significantly less ($p < .05$) time than those being trained by the unstructured method.

With competency being defined as being able to start-up production, develop quality pipe, and to recover from two consecutive production problems without losing production flow, the average times to achieve competency for both the structured and unstructured training groups was measured. It was found that the structured training method 4.6 hour mean was significantly less ($p < .005$) than the 16,3 hour mean for the unstructured group. Therefore, Hypothesis I is accepted. A summary of the data is found in Table 1.

Figure 1 provides a graphic comparison of the relative times to achieve competency. The interpretations can be that structured training method will take 72.0 per cent less time than the unstructured method, or that the unstructured training method constitutes a 250 per cent increase in time to reach competency from the structured method.

TABLE 1

One Tailed "t" Test of Means of Times for
Structured and Unstructured Training
Groups to Obtain Competency

Trainee Training Time in Hours to Reach Competency

Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	326	16.3	5950
Structured	20	91	4.55	4.29

df = 38 5 = 2.8609 ($p < .005$) significant at the .05 level.

Research Hypothesis II: Trainees receiving training by the structured method will achieve significantly higher ($p < .05$) in job competence at the four hour, eight hour, and twelve hour time intervals than those being trained by the unstructured method.

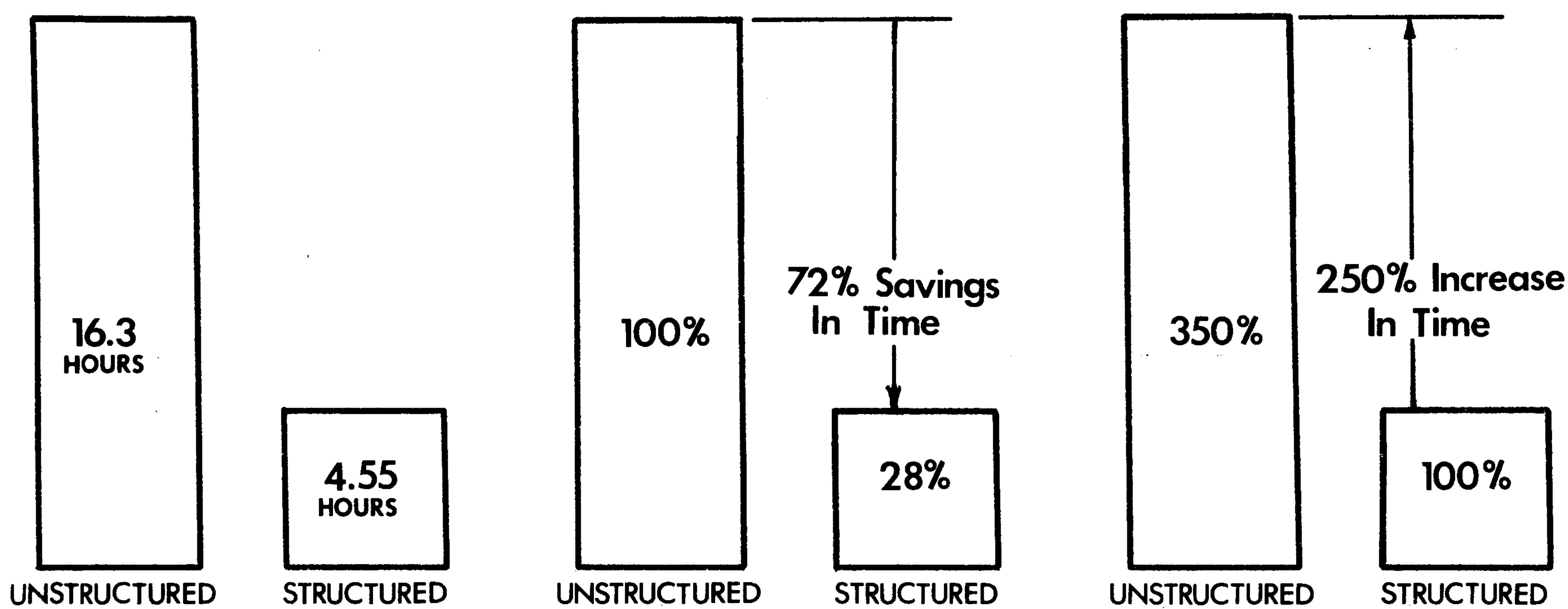
At the four hour interval, the 87.5 per cent competency of the structured group was significantly higher ($p < .01$) than the 28.8 per cent competence achieved by the unstructured group. At the eight hour interval the 100 per cent competency was not significantly higher ($p > .05$) than the 55 per cent competence achieved by the unstructured group. At the twelve hour interval the 100 per cent competence of the structured group was not significantly higher ($p > .05$) than the 77.5 per cent competency achieved by the unstructured group.

With the strength of the fourth hour comparison, the closeness of the eighth hour, and continued positive trend in the twelfth hour, Hypothesis II was tentatively accepted. Data for these comparisons are found in Table 2.

Figure 2 provides a visual comparison of the relative time interval competency levels between the structured and unstructured training groups.

FIGURE 1

Times to Reach Job Competency Under Structured and Unstructured Training Methods



Average Trainee Time Taken to Achieve Job Competency

Per Cent Differences Utilizing Unstructured Training as a Base

Per Cent Differences Utilizing Structured Training as a Base

TABLE 2

One Tailed "t" Tests of Means for Percentages of Job Competency Among Structured and Unstructured Training Groups

Trainee Per Cent of Job Competency After Four Hours of Training

Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	575	28.8	28125
Structured	20	1150	87.5	156250

df = 38 t = 2.6645 ($p < .01$) Significant at the .05 level

Trainee Per Cent of Job Competency After Eight Hours of Training

Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	1100	55.0	71250
Structured	20	2000	100.0	200000

df = 38 t = 1.6835 ($p > .05$) Not significant at the .05 level

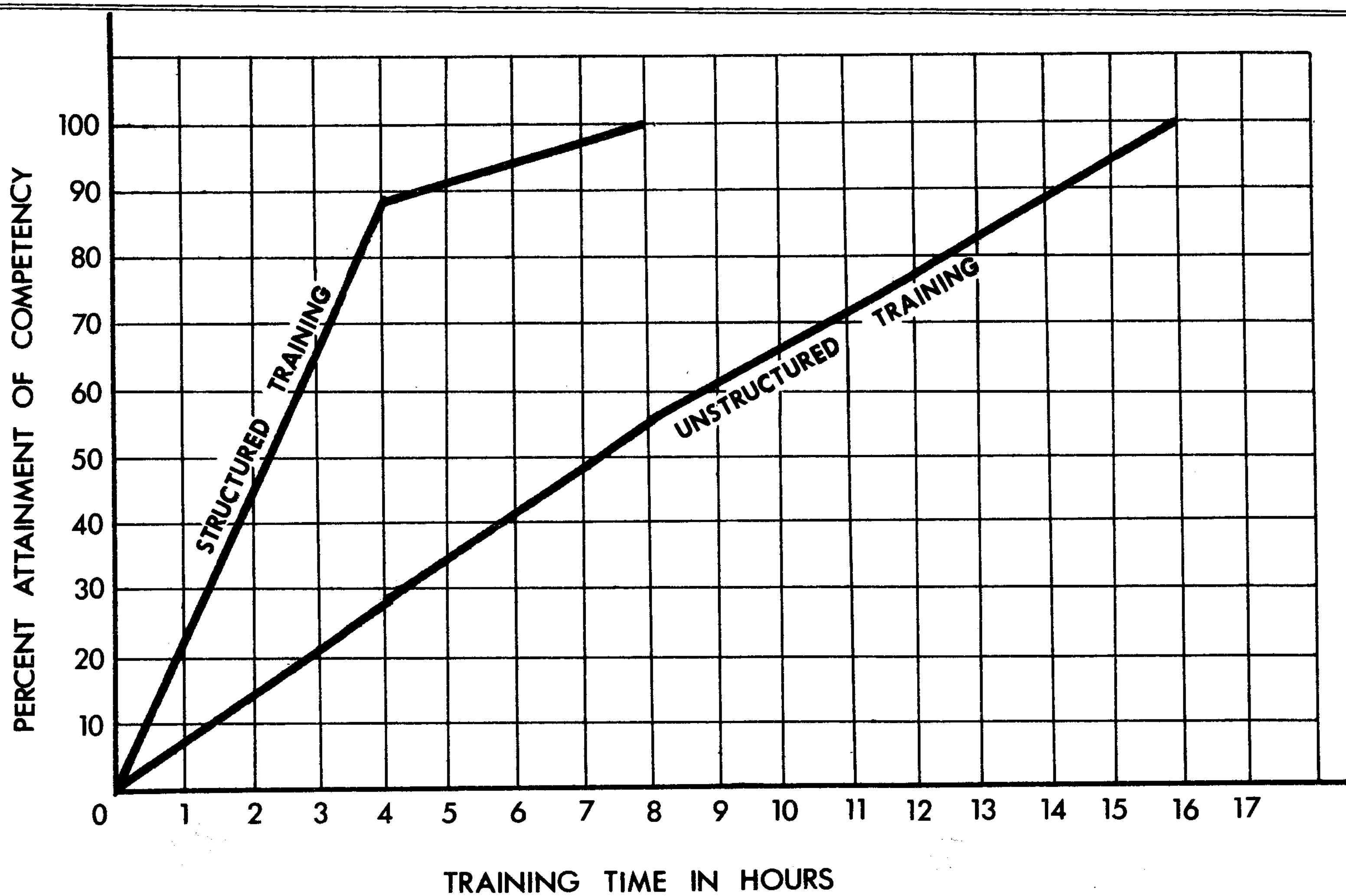
Trainee Per Cent of Job Competency After Twelve Hours of Training

Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	1550	77.5	128750
Structured	20	2000	100.0	200000

df = 38 t = 1.6835 ($p > .05$) Not significant at the .05 level

Figure 2

Hourly Attainment of Job Competency for Structured and Unstructured Trainees



Research Hypothesis III: There will be no significant difference in the average costs to train twenty extruder operators by the structured method as compared to training twenty by the unstructured method.

The \$56.25 average cost to train a group of twenty extruder operators by the structured method was found to be not significantly different ($p > .05$) from the \$57.25 average that it took to train an identical size group by the unstructured method; therefore, Hypothesis III is accepted. A summary of the data is found in Table 3. Figures 3 and 4 provide a visual comparison of the relative costs from one to twenty trainees between the structured and unstructured methods. One can easily see that the development costs for a structured training program become diminished as the numbers of trainees increase. Therefore, to support the development of a structured training program for two trainees

TABLE 3

Two Tail "t" Test Means of Costs for Structured and Unstructured Training Groups

Monetary Costs to Train 20 Extruder Operators

Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	1144.90	57.25	65551.25
Structured	20	1125.03	56.25	63281.25

df = 38 t = .0542 ($p > .9$) Not significant at the .05 level

would require criteria more powerful than normal training costs. Some examples would be very costly production material where waste cannot be tolerated, safety considerations, or a fixed available time to train.

Figure 3

Cost Comparisons Between the Unstructured and Structured Training of Twenty Individually Trained Semi-Skilled Workers

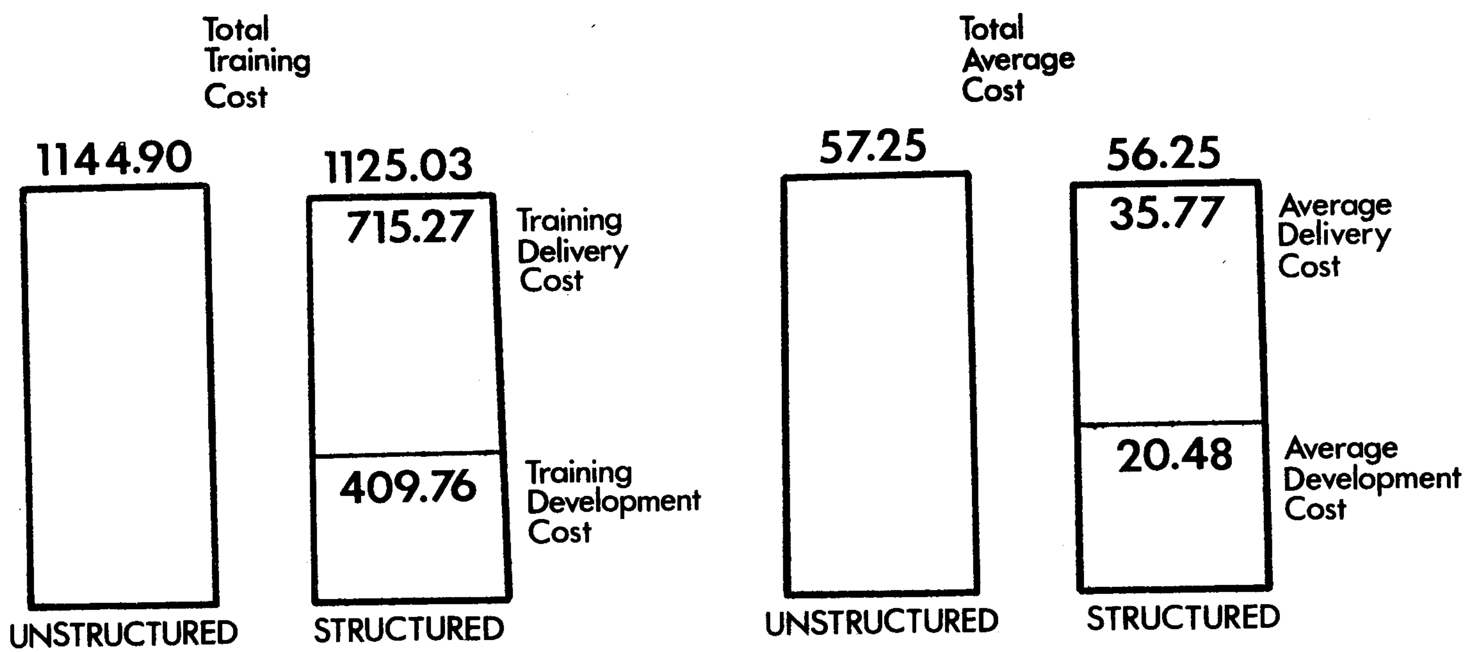
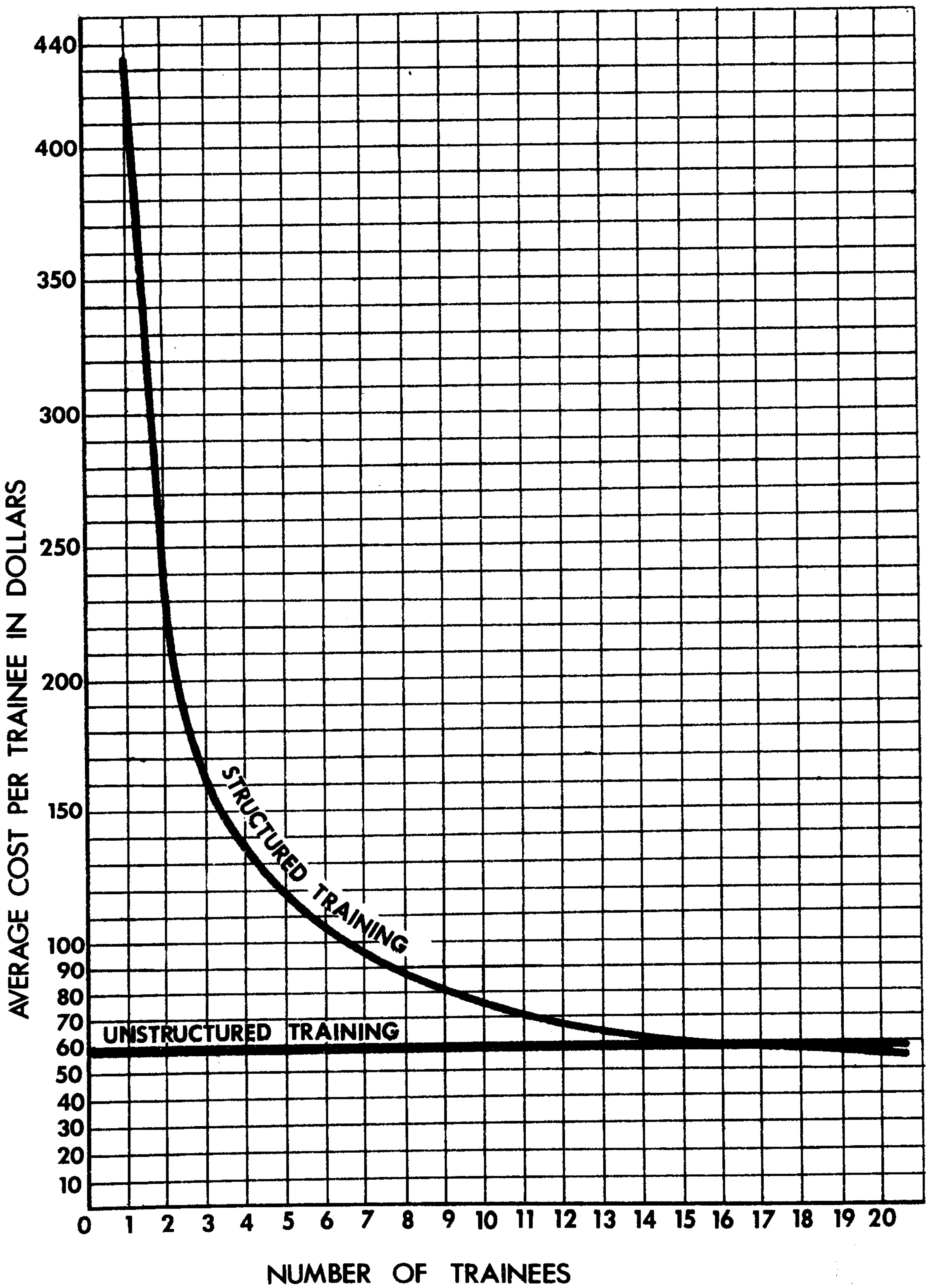


Figure 4

Cost Comparisons Between the Unstructured and Structured Training of One Through Twenty Semi-Skilled Workers



Research Hypothesis IV: There will be no significant difference in the average production losses per trainee via the structured method as compared to those of the unstructured method.

Training under both the structured and unstructured methods resulted in reductions from standard minimum production rates. The average 2.91 pounds of production loss resulting from structured training was found to be significantly less ($p < .01$) than the 9.35 average pounds of production loss resulting from the unstructured training. Therefore, the Hypothesis IV was rejected in that significant differences did occur. Table 4 summarizes the data from the statistical comparison and Figures 5 and 6 visually illustrates the differences.

TABLE 4

Two Tail "t" Tests of Significance Between Production Loss Means of Structured and Unstructured Training Groups

Trainee Production Rate Losses in Pounds of Plastic During Training

Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	187.03	9.35	1528.7
Structured	20	58.20	2.91	207.5

df = 38 5 = 3.0093 ($p < .01$) Significant at the .05 level

Trainee Production Waste in Pounds of Plastic During Training

Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	440.64	22.03	6226.86
Structured	20	105.81	5.29	613.1

df = 38 t = 3.9481 ($p < .001$) Significant at the .05 level

Figure 5

Comparison of Losses in Production Rates (Pounds of Raw Material) Resulting From Unstructured and Structured Training

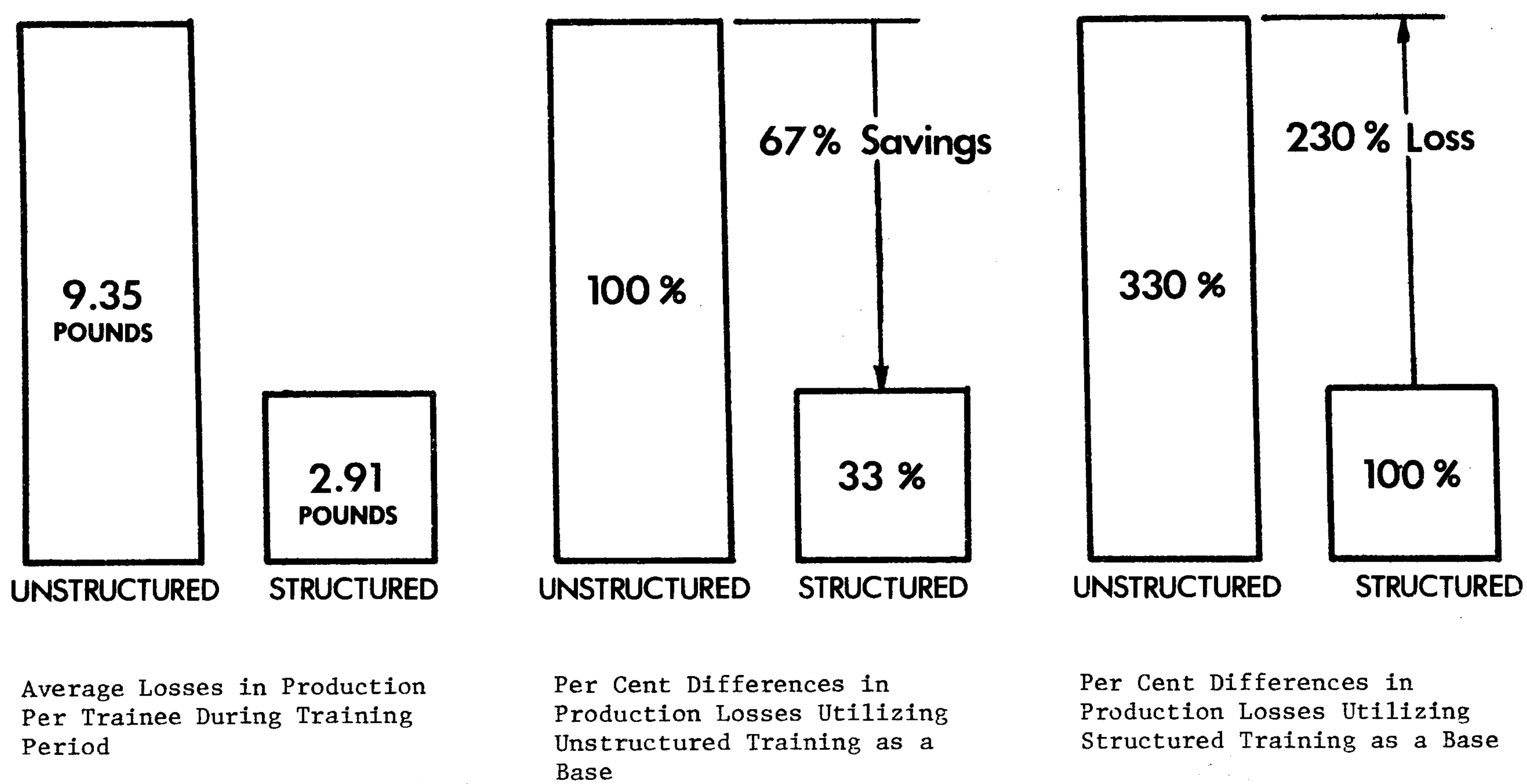
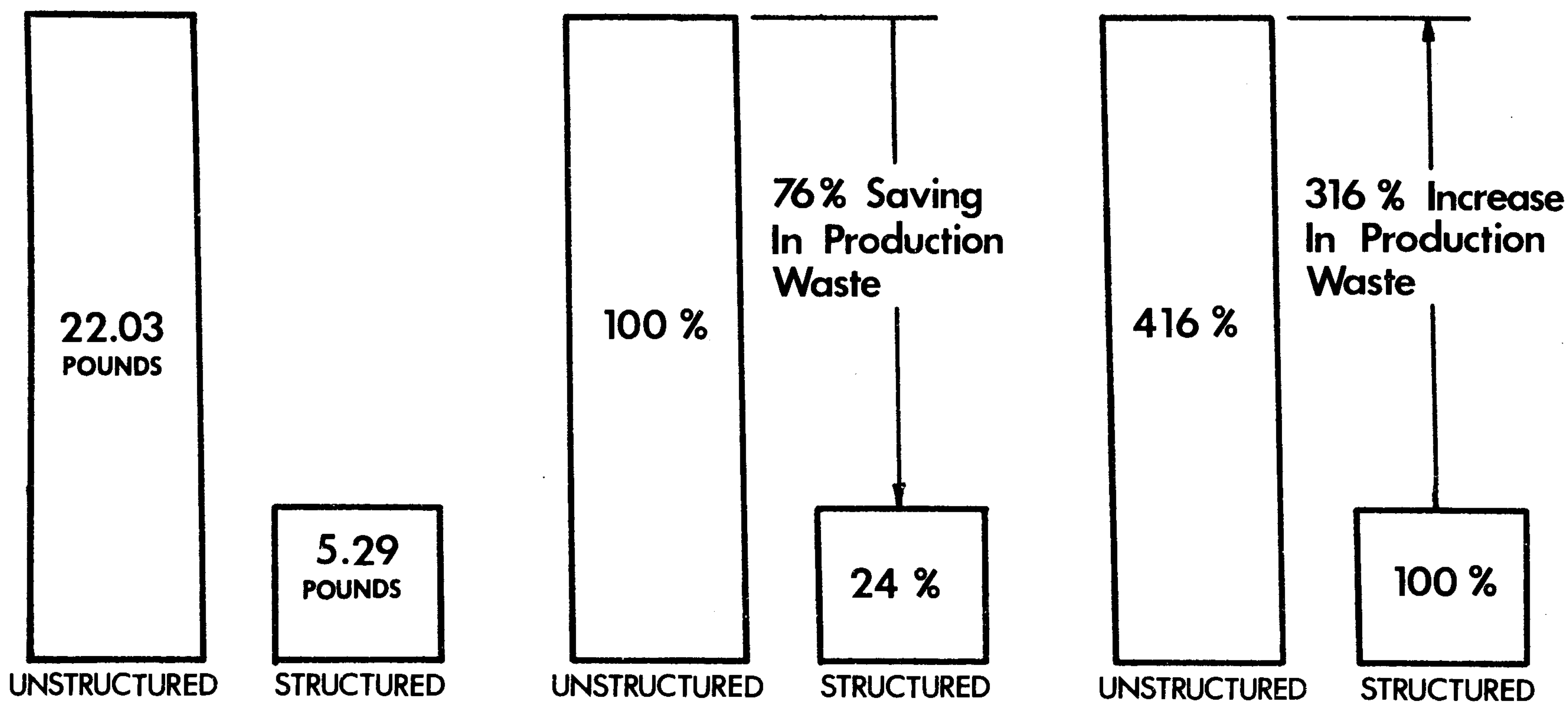


Figure 6

Production Waste (Pounds of Raw Material) Comparisons Between Unstructured and Structured Training



Average Waste Per Trainee During Training Period

Per Cent Differences in Waste Utilizing Unstructured Training as a Base

Per Cent Differences in Waste Utilizing Structured Training as a Base

The approximate 70 per cent reduction in production losses due to going from unstructured to structured training is dramatic. This percentage comparison can be useful in projecting the potential returns for very specific training need situations.

Research Hypothesis V: Trainees receiving structured training will resolve a significantly larger percentage of production problems than trainees receiving unstructured training.

The 80 per cent rate of success in resolving production problems by the structured training program trainees was significantly higher ($p < .025$) than the 33 per cent rate of success by unstructured training program trainees. Hypothesis V was accepted. The suporting statistical information is contained in Table 5 with Figure 7 portraying the visual comparison.

TABLE 5

Oen Tail "t" Test of Means Between Percentages of Solved Malfunctions Among Structured and Unstructured Training Groups

The Per Cent of Malfunctions Solved of the Total Malfunctions Injected per Trainee

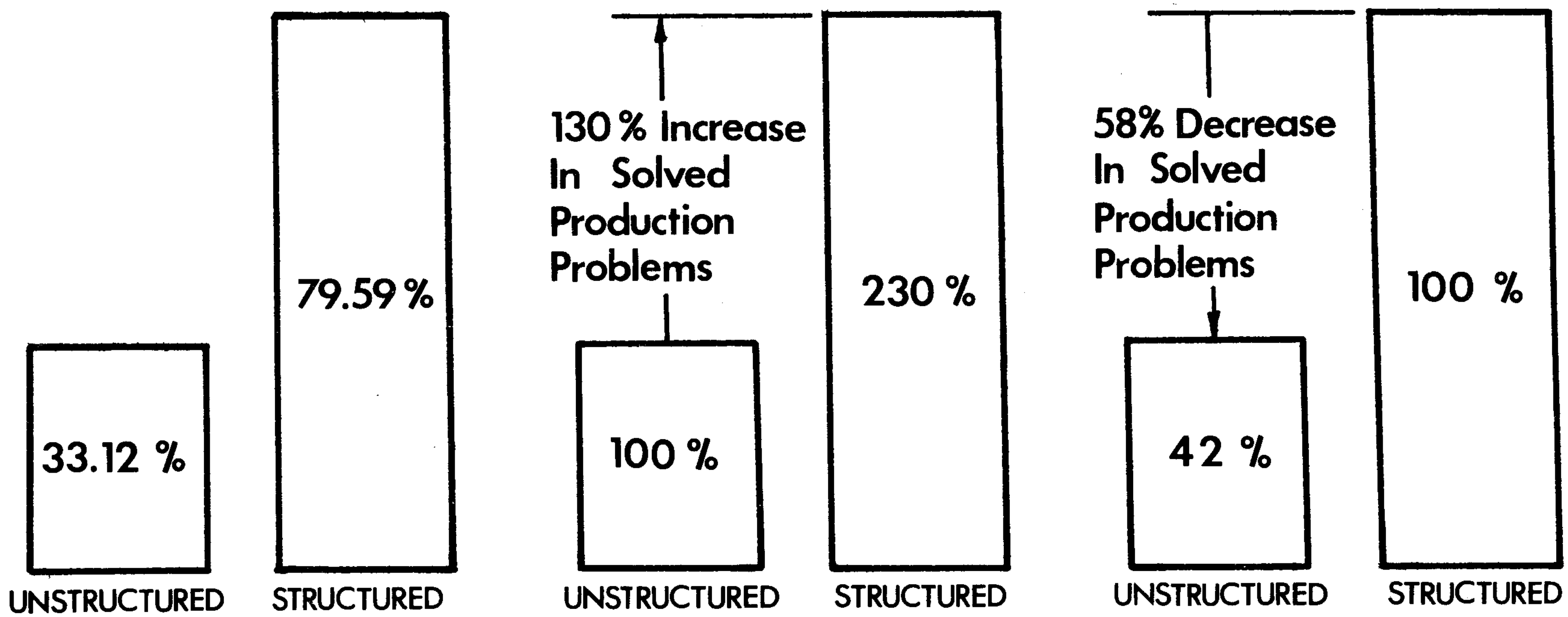
Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	713.26	35.66	27127.27
Structured	20	1661.0	83.05	145937.00

df = 38 t = 2.2207 ($p < .025$) Significant at the .05 level

Obviously, expensive production down-time or difficult start-up procedures would make the reported differences of even greater concern.

Figure 7

Comparison of Percentages of Solved Production Problems Between Unstructured and Structured Trainees



Percentages of Total Production Problems Solved

Per Cent Differences in Production Problems Solved Utilizing Unstructured Training as a Base

Per Cent Differences in Production Problems Solved Utilizing Structured Training as a Base

<u>Research Hypothesis VI</u>: There will be no significant difference in attitudes toward the job and training among structured method trainees as compared to unstructured method trainees.

While the attitudes toward the job by the structured training trainees were more positive, they were not significantly ($p < .8$) different from the trainees in the unstructured training group. Hypothesis VI, therefore, was accepted. The summary of the comparative data is contained in Table 6.

TABLE 6

Two Tail "t" Test of Trainee Mean Attitudes Between Structured and Unstructured Training Groups

Trainee Attitudes Toward Job and Training

Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	1039	51.95	55089
Structured	20	1167	58.35	68973

df = 38 t = .3541 ($p < .8$) Not significant at the .05 level

CHAPTER V

SUMMARY AND CONCLUSIONS

Restatement of the purpose of the study

The purpose of this study was to conduct an experimental comparison of the structured versus unstructured training of semi-skilled production workers. To accomplish this broad undertaking, seven major sub-problems were pursued in depth. They were:

1. To select a production job representative of those semi-skilled jobs in the Johns-Manville Products Corporation.

2. To characterize and develop an unstructured training program for the selected production job that is representative of the Johns-Manville unstructured training practice.

3. To characterize and develop a structured training program for the selected production job that is representative of the Johns-Manville structured training practice.

4. To select trainees that are representative of a Johns-Manville production worker profile.

5. To develop methods for evaluating the production product, worker competence, time, cost effectiveness, and worker attitudes.

6. To execute the training experiment and collect the data.

7. To analyze the data by making comparisons to evaluate the effectiveness of the two training methods.

Results and conclusions

Research outcomes resulting from each of these pursuits have been discussed or presented in depth in this report. The formal conclusions from this research in terms of six hypotheses or sub-points of number seven above are as follows for the pipe extruder operator's job:

1. Training time required under the unstructured method is significantly higher ($p < .005$) than the structured method.

2. At the four hour training time interval, trainees under the structured training had achieved a significantly higher ($p < .01$) level of job competence than the unstructured trainees. Though statistically significant differences were not found at the eight and twelve hour intervals, there is substantial difference in training times.

3. There was no significant difference ($p > .9$) in the costs to train twenty operators by the structured method than by the unstructured method.

4. Production losses were significantly greater ($p < .01$) under the unstructured method of training than under the structured method.

5. Trainees from the structured training program were able to resolve a significantly higher ($p < .025$) percentage of production problems than those trainees under the unstructured method.

6. There was no significant difference ($p < .8$) in attitudes toward the pipe extrusion job among structured and unstructured trainees.

As with any research, caution is given to the reader concerning the tentativeness of the above statements. They should understand the test of replication in order that the statements approach level of "truth."

Observations

Several observations were made in the conduct of this Industrial Training Research Project that are worth noting. They are:

1. It is believed that controlled industrial training research, such as this study, may be impossible to conduct in on-going plant operations. The variables are so complex that controlling them in a simulated situation is, in itself, very difficult.

2. The simulated setting in a University industrial manufacturing laboratory was believed to be an ideal setting for conducting industrial training research. The face validity was high for both the researcher, visiting industrialists from Johns-Manville Corporation, and for the trainees (as judged by the researchers). Nothing occurred during the 14 months of the research to discredit the simulation decisions that were implemented.

3. The job competency attainment under the unstructured training method was in an almost perfect steady linear progression over time.

4. Training to job competency has been and remains a problem for the unstructured method. The looseness of the unstructured method often carries with it a looseness in evaluating attained levels of competency. Many believe that those trained via unstructured methods never reach competency and we never know it. Research that compares unstructured and structured methods must be judged on identical competency criteria.

5. Structured training program trainees responded more slowly and purposefully to their job tasks than did unstructured trainees and invariably relied on their job aids and manuals.

Recommendations for further research

The following recommendations for further research are presented in descending order of importance:

1. Re-examination of existing project data to determine its usefulness in raising and/or answering additional research questions.

2. Develop and validate a method for operationalizing the cost-effectiveness model as a cost-estimate tool for industrial training.

3. Conduct a longitudinal study on the effects of structured versus unstructured industrial training methods.

4. Utilizing the existing ITRP research efforts, begin replication with manipulation of single variables (e.g., task complexity, and trainee profile) so as to establish the generalizability and/or patterns of change resulting from training variables.

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DEFINITION OF TERMS

Analysis Time - total man hours to produce analysis of the job.

Design Time - total man hours to design the training program.

Material Cost - all material costs incurred from onset through completion of one training program. These costs include supplies to facilitate training program development (secretarial, graphics work, travel, duplicating, display boards, training aids, etc.)

Reproduction Costs - all costs incurred in duplicating additional copies of the completed training program for training purposes.

Trainee Time - Total man hours and resulting salary costs incurred for trainee to reach job competency.

Instructional Hardware - shelf items that are purchased to facilitate the training program (e.g. production machine to be used just for training; filmstrip projector, tape recorder)

Instructional Software - shelf items of instructional content that are purchased to facilitate the training program (e.g. manufacturers operating manual; filmstrip/transparencies).

COSTS OF TRAINING

Training costs can be split into three groups, fixed, variable, and total (Wheeler, 1969, p. 14). The ratio comparisons of these costs to returns then determine the economic benefits of a training program. This method provides a detailed analysis of training costs. A broader look at training economics involves a process of calculating an investment cost for training and comparing it to certain returns from that investment (Furst, 1970, p. 30). The proposed cost effectiveness model for the Industrial Training Research Project includes the use of both the above plans. In addition, information unique to the Johns-Manville Products Corporation cost-effectiveness terms and practices is considered.

For this study the costs for training can be classified as either fixed or variable. Fixed costs are costs that do not vary even though numbers of trainees, training time, or training program development varies. Variable costs are costs that change as the number of trainees, training time, and training program development varies (Cullen & Sisson, 1974). Example: if regular production equipment (which is a fixed cost for production) is used for training, the losses in production are considered a variable cost. While individual operations uniquely describe what is to be considered fixed and variable costs, for this discussion only cost categories will be specified.

Structured Training Program Training Costs

The following are the training cost categories for the structured training program as characterized in this study (see Working Paper Number Two):

1. Training Development
    - A. analysis time
    - B. design time
    - C. material costs

2. Training Materials - expendable

   A. cost of reproducing copies of developed training program.

3. Training Materials - nonexpendable

   A. instructional hardware
   B. instructional software

4. Training Time

   A. trainee time
   B. trainer time

5. Production Losses Resulting From Training

   A. production rate losses
   B. material losses

<u>Unstructured Training Program Training Costs</u>

The following are the training cost categories for the unstructured training program as characterized in this study (See Working Paper Number Two):

1. Training Time

   A. trainee time

2. Production Losses Resulting From Training

   A. production rate losses
   B. material losses

	Lbs. raw material (input)
−	Lbs. quality material (output)
	Production loss

TRAINING RETURNS

The training return of the training program (either structured or unstructured) is a competent production worker. To evaluate a competent production worker one must detail the competencies and evaluate them. The combined component evaluations determine the total evaluation. The following outline is utilized to summarize the procedures for assessing the returns of training.

1. Production Task Performance

   A. trainee has reached job competency via training (structured or unstructured training program)

      1) trainee can successfully perform job start-up
      2) trainee can maintain set standard of plastic tubing
      3) trainee can successfully perform in production malfunction performance tests.
      4) trainee can successfully perform job shut-down

   B. trainee is satisfied with his training and his job.

2. Collect Data on Task Performance Returns

   A. measurements of task performance

      1) time (to reach competency, production curtailed, start-up)
      2) production rate
      3) performance test
      4) product quality
      5) raw material useage

   B. measurement of trainee attitudes toward his training and his job.

3. Monetary Value of Returns

   A. convert trainee performance data to a monetary values

   B. returns of structured training program and unstructured training program are totaled.

<u>DATA COLLECTION PROCEDURES</u>

1. Time - job time (time clock)

2. Production Rate - Number of 3 foot lengths of quality pipe per hour of production or a specified minimum measured output within a designated time period.

3. Trouble Shooting - Reaction to injection of machine malfunctions via performance test (down time, loss of tubing, time of malfunction injection vs. time to respond to malfunction, time to correct malfunction).

4. Training Program Costs - List total costs to develop structured and unstructured training materials and program.

5. Production Down - Time production is completely halted or interrupted.

6. Material Efficiency - Weight of raw material supplied to the machine versus weight of scrap and amount of quality product produced (weight raw material supplied, scrap, and hour bundles of quality tubing).

7. Training Time - time consumed to train a trainee to reach job competency.

DATA ANALYSIS AND EVALUATION

The following comparisons will be used to evaluate the effectiveness of the two training methods:

1. Training time required of the unstructured training program as compared to training time required of the structured training program to produce a competent production worker.

2. A comparison of levels of production worker competence by time intervals between the two industrial training methods.

3. The total development costs and returns of the structured training program as compared to the costs and returns of the unstructured training program.

4. The production losses of the structured training program versus the unstructured training program.

5. The reactions of the structured training program operators to production problems (malfunction performance test) versus the unstructured training program operators.

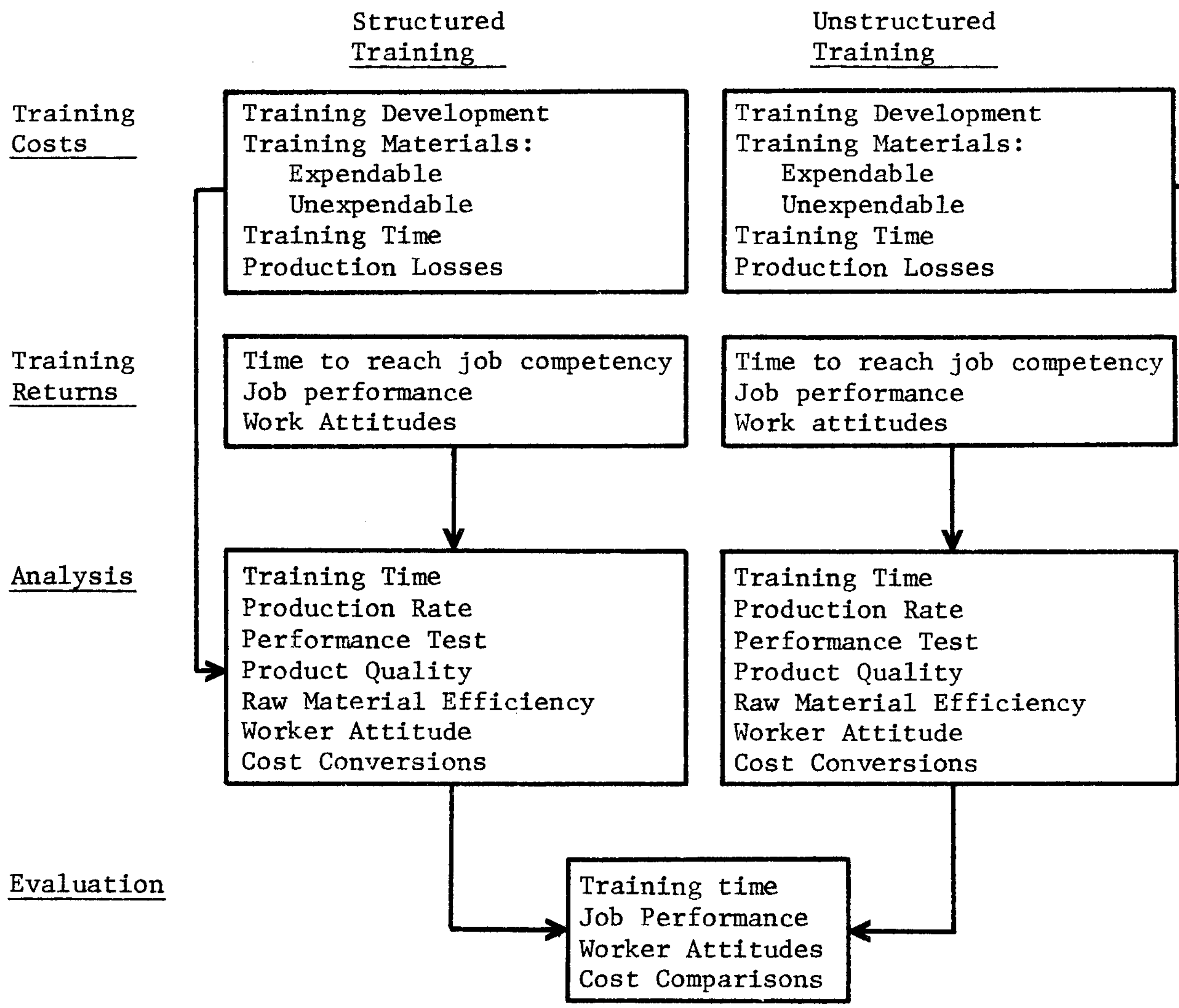
6. The attitudes of the trainees in the structured program towards their training, trainer and job versus those in the unstructured program.

COST-EFFECTIVENESS MODEL

The following is the overview program procedure and model for evaluating the cost-effectiveness of industrial training programs. The specifics of the costs, returns, and analysis have been discussed previously. The graphic representation of the model is presented in Table 1. For both the structured and the unstructured training programs, each variable under training costs and training returns should be quantified. For those that are expressed in non-monitary indexes (e.g. time), their monitary equivalency should be calculated whenever possible. These figures can then be used for the analysis and evaluation stage.

Table I

INDUSTRIAL TRAINING COST-EFFECTIVENESS MODEL



CONCLUSION

The cost-effectiveness comparison between the structured and unstructured training programs is determined by analyzing the training variables, converting them to monetary equvalents, and then conducting a cost comparison. Obviously, individual variables such as "time taken to reach competency" will be compared and reported as additional indexes of effectiveness.

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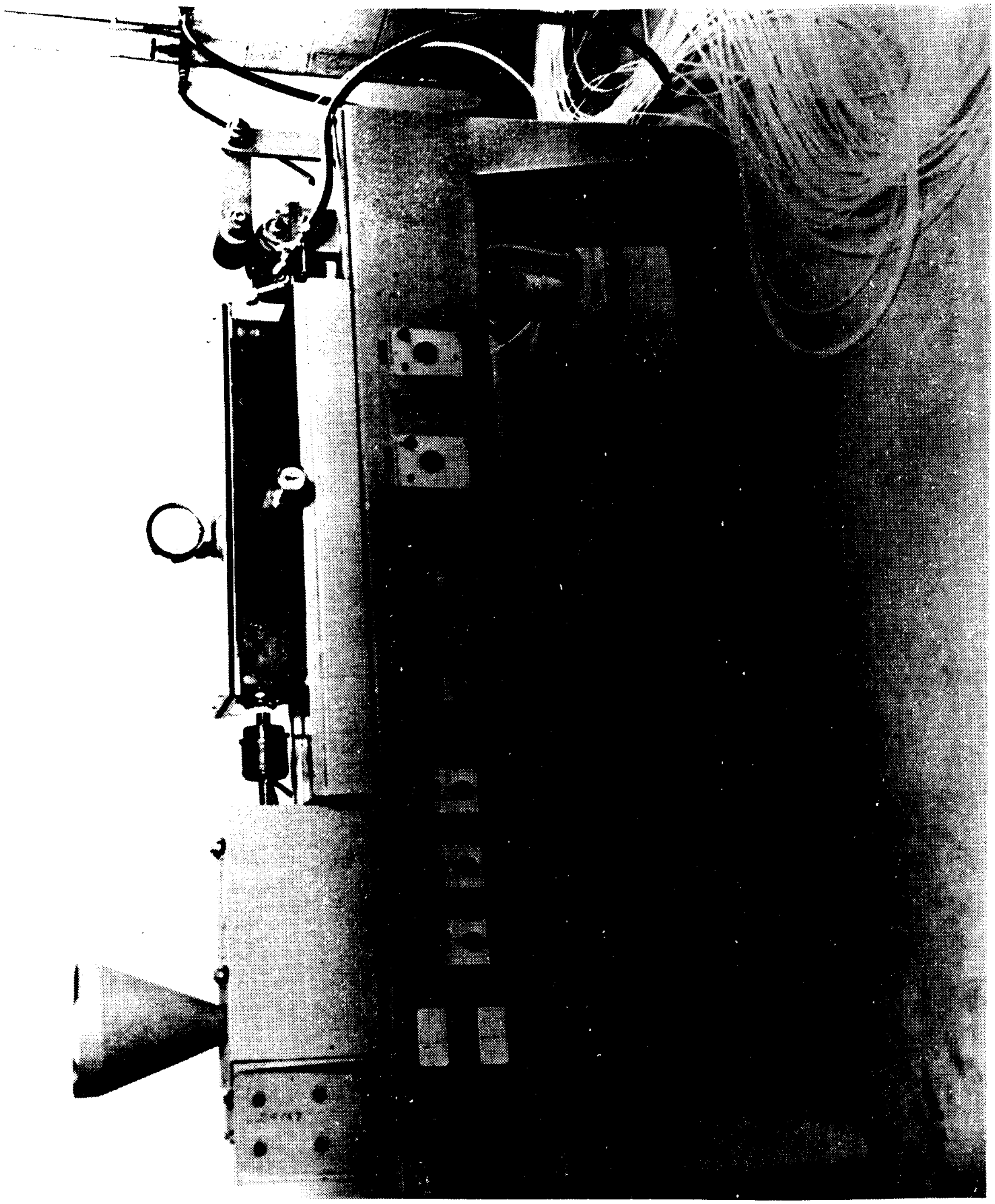
APPENDIX B

Description of the Rainville Extruder



UNEX ED-X-TRUDER SYSTEM

The ED-X-TRUDER system is a small extruder and versatile take-off equipment. The basic ED-X-TRUDER, shown below, is a 3/4 inch, 20 to 1 L/D ratio extruder, fitted with a breaker plate and die for extruding 1/8 inch rod, a cooling trough, and a pull-off unit. The extruder and pull-off unit are run by separate variable speed motors. The temperature of the extruder barrel and die is controlled and indicated by three separate zone controllers. The hopper area of the extruder is water cooled. An ammeter and tachometer are supplied for indicating the extruder motor current and screw speed. The plasticizing capacity is rated at 8 pounds of HDPE per hour.

The basic unit is supplied with a 1/8 inch diameter die for rods or strands. Other dies are available, as options, for rods and profiles of various sizes and shapes. Consult the list of optional equipment below.

Other take-off units are used interchangeably in place of the cooling trough. These include a vacuum sizer for tubing, a three-roll sheet finishing unit, a blown film unit, a chill-roll casting unit for film, and an extrusion coating unit. The accessory equipment is so designed that any individual system can be installed and aligned in a matter of minutes.

All accessory items are driven from the pull-roll drive by means of a one-chain connection.

The winder rolls on the film and coating lines are essentially the same as those used on the sheet line (see description of this on the opposite page).

RAINEX SPECIFICATION AND INFORMATION SHEET

Specifications on the Extruder:
Model 3/4 x 20:1 ED-X-TRUDER

Barrel Size (ID), Inches	3/4
Length to Diameter (L/D) Ratio	20 to 1
Barrel Material	4140 Steel Alloy*
Screw Type	Constant Pitch Metering
Compression Ratio	2 to 1
Screw Material	Nitrided 4140 Steel Alloy*
Melt Capacity, Pounds of High Density Polyethylene per hour	8
Number of Heating Zones	3
Heater Type	Mica Band
Heating Capacity, Watts	1600
Heat-up Time, Hours	1/2
Motor Horsepower	3/4
Motor Speed Control Type	SCR
Screw Speed, Maximum RPM	120
Type of Speed Reducer	Worm Gear
Gear Ratio	15 to 1
Transmission Horsepower with a 1.25 Service Factor at 100 RPM	3/4
Thrust Bearing	Ball Type
Bearing Life, B-10 at 1500 PSI, hrs	50,000
Electrical Circuit Required	115-volt, 30-Amp
Floor Space Occupied by Basic ED-X-TRUDER	86" x 14"

*Other materials available as options.

APPENDIX C

Working Paper Number Two:

Plastic Extruder Operator Job Analysis[1]

February, 1974

JOB DESCRIPTION

The operator is a semi-skilled worker who transforms raw plastic into plastic tubing through the use of an extrusion machine. The operator's work is performed in a manufacturing environment with other extrusion machines operating next to him. The operator possesses a fundamental knowledge of the extruder and the plastic extrusion process. He is capable of manipulating hand tools necessary for performing this job.

The operator can start up the fully assembled machine short of set-up of the pipe extrusion equipment. The operator must be able to perpetuate the production process and restart the production of pipe if the machine or its components curtail the pipe production. The operator is fully responsible for the quality of pipe manufactured, gathering and bundling of quality pipe and plastic waste, and tagging and recording of production output.

JOB TASKS

The following list constitutes the seven major tasks involved in the plastic extruder operator job:

A. Preparing the job
B. Starting-up the extrusion machine
C. Threading the vacuum-cooling tank
D. Adjusting speed of production
E. Developing the tubing
F. Maintaining production and quality control
G. Shutting-down the job

1 Industrial Training Research Project (funded by Johns-Manville Corporation) Richard A. Swanson, Director and Stephen A. Sawzin, Research Assistant Bowling Green State University

TASK DETAILING SHEET

Preparing the Job

1. Examine the extruder for proper serviceable operation.

    A. Assure proper connection of accessories
        1. Extruder Dies
        2. Sizing Die
        3. Vacuum and Cooling Tank
        4. Tank Exit Gasket
        5. Cooling Water
        6. Electrical Power
        7. Vacuum Pump
        8. Raw Material Supply

    B. Cleanliness; Water and Pellets

    C. Necessary Hand Tools
        1. Pliers
        2. Tin Snips
        3. Knife

    D. Place pliers and tin snips on extruder bed

    E. Quality control tools
        1. Pipe Test Device
        2. Cut-off Saw

2. Review "Work Order Specifications"

    A. Raw Material

    B. Product

    C. Dimensional Specifications

    D. Visual Quality Specifications

    E. Recommended Extruder Settings

TASK DETAILING SHEET

STARTING-UP THE EXTRUSION MACHINE

1. Turn on cooling water-open approximately one turn.

2. Main Power

    A. Make sure all switches are off and dials set to the zero position
    B. Main Power ON
    C. Push in re-set, green, button

3. Turn on temperature zones-note job sheet for recommended temperature.
    A. Zone 1 (Barrel)
    B. Zone 2 (Universal Adapter)
    C. Die Zone (Extruder Die)

4. Warm-up time for zones: 15 minutes

5. Check and/or fill the vacuum-cooling tank with water to the minimum water level mark

6. Check for zone temperatures on temperature.

    A. Zones On Temperature, Yes-No
    B. If No-Adjust

7. Place extruder screw switch to the start position

8. Place take-up roller speed switch to the start position

9. Dial take-up roller (take-up) speed

10. Turn on the vacuum pump

TASK DETAILING SHEET

THREADING THE VACUUM-COOLING TANK

1. Adjust the amount of lubricant water in sizing die. The valve should be opened one full turn to allow cooling water into the sizing die.

2. Extrude plastic slowly (approximately 40 RPM run speed).

   A. This is done by turning the run speed RPM Dial to the necessary speed to extrude plastic.
   B. As the plastic is being extruded twist the extrudent to a diameter necessary to enter the sizing die and the vacuum-cooling tank (the twisting is done by using pliers to grasp the extrucent and twist it).

3. Stop "run speed" (turn the RPM Dial to zero)

4. Once twisted, cool the plastic twist portion by splashing water on it.

5. Cut-off plastic roughage that was held by the pliers with the tin snips.

6. Grasp the twisted plastic with pliers and push it through the sizing die.

7. Grasp the plastic by hand inside the tank.

8. Dial "run speed" to "50"

9. Hand pull the plastic through the tank and try to keep a uniform diameter pipe while, NOTE: The plastic tube may collapse at this time, this is expected.

10. Feed the plastic through the exit gasket and into the take-up rollers.

11. Slide the tank forward keeping it tight against the side and front guides.

TASK DETAILING SHEET

ADJUSTING SPEED OF PRODUCTION

1. Check the specifications for the production rate as given on the work order specifications.

2. Using the work specifications, set the RPM dials for the extrudent run speed and the take-up roller speed.
   NOTE: The dials should be adjusted at the same speed to keep an even flow of plastic through the tank.

3. Constantly cut-off extruded plastic, with tin snips, exiting the rollers.

4. Check and correct for build-ups of plastic at the sizing die. This can be done by either increasing the RPM of the rollers or decreasing the RPM of the extrudent plastic output.

TASK DETAILING SHEET

DEVELOPING THE TUBING

1. Place the lid on the vacuum-cooling tank

    A. Use four wing nuts to fasten the lid-one on each corner stud
    B. Fasten nuts snug-tight

2. Open "water-in" valve to fill tank with cooling water.

3. Turn "water-in" valve off when water reaches the maximum water level mark.

4. Turn off sizing die water valve, hand tight.

5. Turn cooling tank vacuum adjustment clockwise to obtain maximum vacuum.

6. As pipe blows up, the exit gasket-to-pipe seal is developed, and the tank vacuum rapidly increases.

7. Turn vacuum adjustment counterclockwise to adjust the vacuum according to the production job sheet.

TASK DETAILING SHEET

MAINTAINING PRODUCTION AND QUALITY CONTROL

1. Check and fill the feed hopper with plastic raw material.

2. Tubing at this time is now properly extruding as per the production job sheet.

3. Preliminary check of the operation

   A. RPM Adjustments
   B. Stretching of the Plastic
   C. Visual Appearance
   D. Slippage of the take-up rollers
   E. Collapsing of the Tubing
   F. Consistent Pressure of Vacuum
   G. Temperature Indicators for Constant Heating Temperatures

   NOTE: Observe extruder screw RPM and motor amperage for a constant, even extrudent output and to check the load on the screw drive motor.

   Increase of amperage indicates an increase of load on the motor. Possible cause of the plastic not melting in zones one and two, remedy by increasing the temperatures in zones one and two.

   NOTE: Constant checking is required to prevent a build-up of plastic at the entrance to the sizing die.

4. Sampling of the Tubing

   A. Cut off approximately 8 inches of tubing from the extruder with the tin snips.
   B. Observe visual qualities of the sample
      1. Smoothness
      2. Ripples
      3. Streaks
      4. Bubbles
      5. Melt
      6. Blow-outs
   C. If not meeting visual qualities adjust the extruder controls as per criteria chart.
   D. Square-off ends of tube sample
      1. Clamp tube in cut-off saw vise
      2. Turn on power-push button
      3. Slowly feed saw into the tubing and cut-off end
      4. Remove the tube from the vise
      5. Repeat the cut-off operation on the other end of the tube
      6. Turn off power-push power off button
      7. Trim off edges of both ends with knife

E. Outside Diameter Check
   1. Insert tube in outside diameter test device
   2. Rotate the tube
   3. Read the dial indicator at several intervals with hand removed.
   4. Indicate the maximum positive and negative indices
   5. Accept or reject tubing according to the specifications, on the job sheet, within the tolerances.

F. Wall Thickness and Concentricity Test
   1. Insert tube in test device
   2. Apply downward pressure on tube with thumb
   3. Rotate tube
   4. Read the dial indicator indices while rotating the tube
   5. Indicate the maximum positive and negative indices
   6. Accept or reject tubing according to the specifications, on the job sheet, within the tolerances

G. Plan for and Adjust Extruder Controls
   1. By using the trouble shooting chart correct extruder controls that will result in quality tubing based on sample test results.

5. Repeat sampling procedure until pipe meets job standards.

6. Material take-off of standard tubing

   A. Cut pipe with snips in 3 foot, 6 inch lengths
   B. Cut off 3 inches from each end
   C. Trim ends free of plastic burrs
   D. Bundle, tape and tag all tubing (good and bad) for each hour of production.

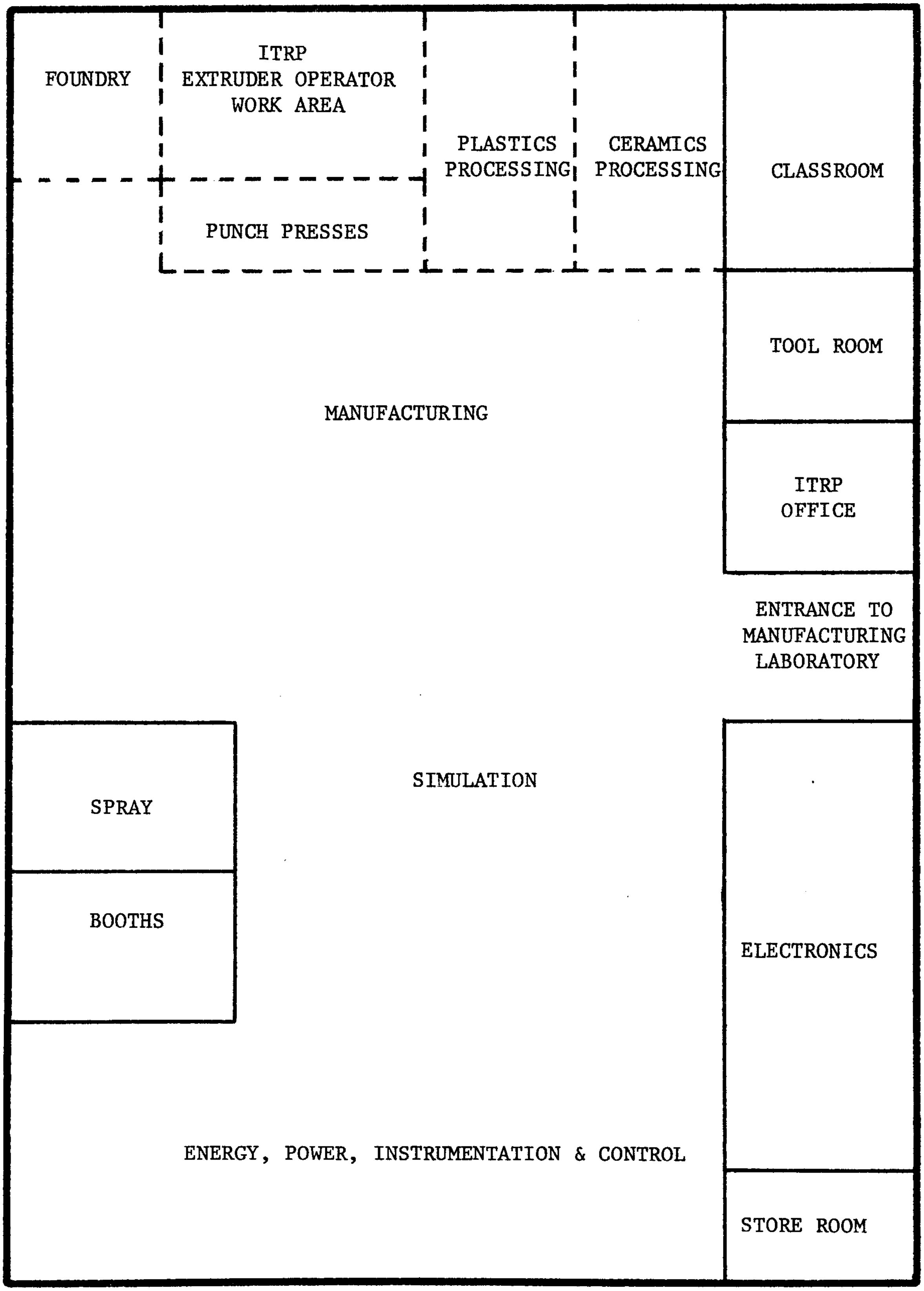
TASK DETAILING SHEET

SHUTTING DOWN THE JOB

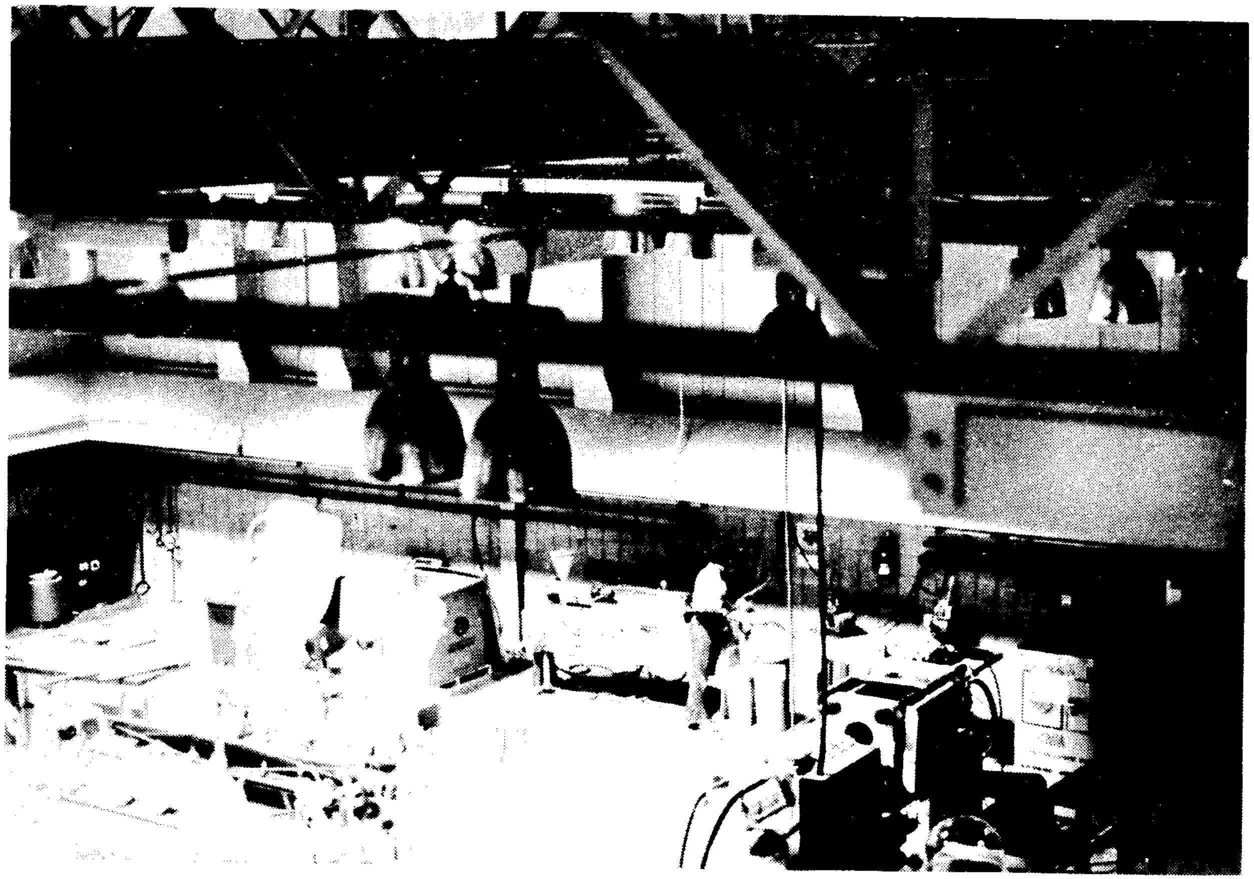
1. Stop extrusion of plastic by turning the extrudent screw RPM dial to zero.
2. Placing screw drive motor switch to the off position.
3. Allow rollers to pull the remaining pipe through the cooling tank.
4. Stop the take-up rollers by turning the take-up speed dial to zero, and placing the roller on-off switch to the off position
5. Turn off the vacuum pump by placing the pump switch in the off position.
6. Allow the water in the vacuum-cooling tank to drain out.
7. Turn the heating zone dials to the zero position
8. Place heating zone power switches to the off position
9. Allow cooling water to remain circulating through the extruder for 10 minutes.
10. Place the main electrical power switch to the off position.
11. Clean-up
    - A. cut-off excess
    - B. water and pellets
    - C. other

APPENDIX D

Layout of ITRP Work Area and BGSU Manufacturing Laboratory


FOUNDRY
ITRP
EXTRUDER OPERATOR
WORK AREA
PLASTICS
PROCESSING
CERAMICS
PROCESSING
CLASSROOM
PUNCH PRESSES
TOOL ROOM
MANUFACTURING
ITRP
OFFICE
ENTRANCE TO
MANUFACTURING
LABORATORY
SIMULATION
SPRAY
BOOTHS
ELECTRONICS
ENERGY, POWER, INSTRUMENTATION & CONTROL
STORE ROOM

Picture of ITRP Extruder Operator Work Area



APPENDIX E

Working Paper Number One

Characteristics of Structured and Unstructured Training Programs[1]

October, 1973

I. Unstructured Industrial Training (buddy-system)

A. Trainer Characteristics

1. Interest in training - No interest with possible negative feelings; to some interest. Rarely will there be persons highly interested in being a trainer.

2. Knowledge of job - Minimal competencies with possible incorrect knowledge of practice; to mastery of the job.

3. Instruction skill - No instruction skills. In terms of sensitivity to the human interaction aspect of instruction, there may be none to some sensitivity.

B. Instructional Materials Available

1. Instructional plan - none available

2. Instructional support materials - None available

3. Proper job tools and equipment - Available, but, may not all be used

C. Instructional Environment

1. Worker-Trainer must maintain production while instructing and thus the actual production activity is the focal point of the training effort.

2. Worker-Trainer is conscious of incentive pay while instructing.

3. Worker-Trainee is distractor in terms of

a. takes worker-trainer time
b. potential personality clash

4. Trainee does not feel that he is being closely observed.

[1] Industrial Training Research Project (funded by Johns-Manville Corporation) Richard A. Swanson, Director and Stephen A. Sawzin, Research Assistant Bowling Green State University

II. Structured Industrial Training (systematic)

A. Trainer Characteristics

1. Interest in training - Has positive to high interest in being a trainer.

2. Knowledge of job - Has all the necessary knowledge and practice to perform the job.

3. Instruction skill - Basic instructor skills with some to much human interaction sensitivity.

B. Instructional Materials Available

1. Instructional plan - Thorough analysis of the job used as a basis for the structured training program.

2. Instructional support materials - Complete self-instructional and/or instructor based structured training program that has been systematically developed and validated.

C. Instructional Environment

1. The trainee is the focal point of the training effort.

2. The trainee feels that he is being closely observed.

APPENDIX F

Foreman Job Characterization

The foreman will act as the direct production and worker supervisor. The foreman's duties and responsibilities are such that as the new worker enters his new job environment the foreman has little time or desire to involve himself extensively in the orientation or training of the new worker. These tasks are performed by existing employees on the job. Normally the foreman would give the new worker a short oral orientation at the job site covering a very general description of the process and would then turn him over to the buddy for training. The existing employee is totally unprepared. The foreman will interact with the new worker only if a situation demands it. The foreman is constantly mobile. He is either supervising his job area or performing the administrative functions of lower management. Interaction between the trainee and the foreman may be further characterized by analyzing the interaction according to stages of training, training progress, and production outcomes. Foreman responses to these varying situations are characterized below.

Stages of Unstructured Job Training

Trainee Introduction:

1. Foreman takes very little time to show the new worker around his job and to his fellow workers.
2. The foreman lacks time to orientate the new worker because of the pressures of other duties.
3. Trainee expectations in the way of performance, work breaks, and work attitudes are not given to the worker by the foreman but by a fellow worker (buddy).

Initial Training Period:

1. Foreman does not initial job training, leaving that duty to a fellow worker (buddy).
2. Rarely if any interaction with the trainee to check on training progress by the foreman.
3. Foreman does not discuss training of the trainee with the fellow worker (buddy) unless the trainee is detrimental to the job environment.
4. Informal run in with the foreman by the trainee may result in introductions that may lead to basic information about the job given to the trainee by the foreman.

Advanced Training Period:

1. Foreman expects improvement in trainee performance, increased production and job knowledge.
2. At this period of the training the foreman interacts casually with the trainee.
3. The interaction is informal and does not relate to the job or training.
4. The trainer may take advantage of trainee's progress and leave the trainee for extended breaks.

Progress During Unstructured Training

The foreman has no schedule for training progress.
The foreman has a value expectation of where the training should stand at a point in time.

Training on Schedule:

1. Foreman indiscretely shows acknowledgement of training progress.
2. Acknowledgement given more to buddy than the trainee.
3. Foreman feels everything is running smoothly therefore performs his duties not worrying or thinking about the training.

Training Ahead of Schedule:

1. Foreman shows appreciation for trainee performance by telling the buddy not the trainee.
2. Appreciation by foreman is minimal to non-existant.

Training Behind Schedule:

1. Foreman concerned only if production is lost and it is the trainees fault.
2. Points out loss in production.
3. Foreman discusses training with the buddy in a formal office meeting.
4. Foreman discusses the buddy's lost money due to inadequate training of the trainee.

Production Outcomes from UNSTRUCTURED Training

DEFINITION: Production Crisis

1. Production consistantly curtailed because of worker inability to start up pipe production or keep production rate up.
2. Failure of extruder to operate correctly or its related components.
3. Worker/trainee can determine the degree of crisis by his actions being either frantic or rational.
4. Failure between the trainee and trainer (buddy) to interact together and communicate thus resulting in loss of production or damage to equipment.

Production Crisis Situation (not Buddy or Trainee fault):

1. Foreman is concerned.
2. Foreman builds anxiety thinking it is the workers fault, anxiety does not diminish once truth is known.
3. Crisis is a nuisance or annoyance to the foreman if it must be handled by him instead of being handled by the trainee or the buddy.
4. Though the crisis is not the workers fault the foreman will reprimand the buddy for allowing the crisis to occur.

Production Crisis Situation (Buddy or trainee fault):

1. Foreman anxiety builds profusely.
2. Foreman shows worker what is wrong but reprimands the workers for their lack of performance in handling the crisis in which they should have been able to solve because of the training.

Normal Production (no problem):

1. Foreman casually interacts with the trainee.
2. Foreman leaves the trainee alone since the production is adequate.
3. Foreman conspicuously absent from the work area.

Normal Production (problems):

1. Foreman usually does not interact. Buddy and trainee to solve problems.
2. If foreman interacts he does so only in an inquisitive way.
3. Foreman may offer suggestions in a rational, analytical, professional manner.
4. Foreman shows no anxiety.

DEFINITION: Casual Interaction

1. Does not deal with the job.
2. Talk deals with sports, hobbies, news items, town talk, personal lives.
3. Deals with the job, pay, performance, production. This interaction is usually a minor amount of interaction in a crisis situation for the trainee or worker-trainer.

APPENDIX G

Structured Training: General and Specific Training Decisions

II. General Decisions

A. Introduction/Overview
B. Specific Job Instruction/"talking and doing phases"
C. Production Problem Training/"Talking and doing phases"

III. Specific Decisions

Parts and Content	Strategies	Estimated Instructional Time
A. Introduction/Overview 1. your training program 2. extrusion principle 3. job overview 4. what to expect next	1. audio cassette tape 2. trainee manual with abreviated script and black and white prints	10 min.
B. Specific Job Instruction 1. preparing the job 2. starting-up the extrusion machine 3. threading the vacuum-cooling tank. 4. adjusting the production speed. 5. developing the tubing 6. maintaining production and quality control. 7. shutting-down the job.	1. instructor based 2. instructor and trainee manuals 3. minimum down time on extruder 4. talk thru entire job while production is maintained by production worker. Solicit verbal responses from trainee and written responses in manual. 5. execute entire job using trainee manual and verbally explaining job trainer and/or ask questions.	120 min.
C. Production Problem Training 1. Extruder Variables a. trake-off speed b. run speed c. vacuum d. heat zone 1 e. heat zone 2 f. heat die zone 2. Production Problems a. blow-out b. bubbles c. bumps-ripples d. melt e. streaks-ridges f. outside diameter oversize	1. instructor based 2. instructor and trainee manual 3. minimum down time on extruder 4. talk thru variables while production is maintained by production worker. Solicit verbal responses from trainee and written responses in manual 5. execute entire problem solving procedures using trainee manual and verbal explaining procedures to the trainer and/or ask questions.	20 min. "talk" 30 min. "action"

g. outside diameter
   under size
h. inside diameter
   over size
i. inside diameter
   under size
j. eccentricity of
   outside diameter
   to inside diameter
k. zero (0) vacuum

APPENDIX H

Trainer Manual

Trainer Manual

Working Paper Number Two:

Plastic Extruder Operator Job Analysis[1]

February, 1974

JOB DESCRIPTION

The operator is a semi-skilled worker who transforms raw plastic into plastic tubing through the use of an extrusion machine. The operator's work is performed in a manufacturing environment with other extrusion machines operating next to him. The operator possesses a fundamental knowledge of the extruder and the plastic extrusion process. He is capable of manipulating hand tools necessary for performing this job.

The operator can start up the fully assembled machine short of set-up of the pipe extrusion equipment. The operator must be able to perpetuate the production process and restart the production of pipe if the machine or its components curtail the pipe production. The operator is fully responsible for the quality of pipe manufactured, gathering and bundling of quality pipe and plastic waste, and tagging and recording of production output.

JOB TASKS

The following list constitutes the seven major tasks involved in the plastic extruder operator job:

A. Preparing the job
B. Starting-up the extrusion machine
C. Threading the vacuum-cooling tank
D. Adjusting speed of production
E. Developing the tubing
F. Maintaining production and quality control
G. Shutting-down the job

1 Industrial Training Research Project (funded by Johns-Manville Corporation) Richard A. Swanson, Director and Stephen A. Sawzin, Research Assistant Bowling Green State University

TASK DETAILING SHEET

PREPARING THE JOB

1. Examine the extruder for proper serviceable operation.

    A. Assure proper connection of accessories
        1. Extruder Dies
        2. Sizing Die
        3. Vacuum and Cooling Tank
        4. Tank Exit Gasket
        5. Cooling Water
        6. Electrical Power
        7. Vacuum Pump
        8. Raw Material Supply

    B. Cleanliness; Water and Pellets

    C. Necessary Hand Tools
        1. Pliers
        2. Tin Snips
        3. Knife

    D. Place Pliers and tin snips on extruder bed

    E. Quality control tools
        1. Pipe Test Device
        2. Cut-off Saw

2. Review "Work Order Specifications"

    A. Raw Material
    B. Product
    C. Dimensional Specifications
    D. Visual Quality Specifications
    E. Recommended Extruder Settings

TASK DETAILING SHEET

STARTING-UP THE EXTRUSION MACHINE

1. Turn on cooling water-open approximately one turn.

2. Main Power

    A. Make sure all switches are off and dials set to the zero position
    B. Main Power ON
    C. Push in re-set, green, button

3. Turn on temperature zones-note job sheet for recommended temperature.

    A. Zone 1 (Barrel)
    B. Zone 2 (Universal Adapter)
    C. Die Zone (Extruder Die)

4. Warm-up time for zones: 15 minutes

5. Check and/or fill the vacuum-cooling tank with water to the minimum water level mark.

6. Check for zone temperatures on temperature.

    A. Zones On Temperature, Yes-No
    B. If No-Adjust

7. Place extruder screw switch to the start position

8. Place take-up roller speed switch to the start position

9. Dial take-up roller (take-up) speed

10. Turn on the vacuum pump

TASK DETAILING SHEET

THREADING THE VACUUM-COOLING TANK

1. Adjust the amount of lubricant water in sizing die. The valve should be opened one full turn to allow cooling water into the sizing die.

2. Extrude plastic slowly (approximately 40 RPM run speed).

   A. This is done by turing the run speed RPM Dail to the necessary speed to extrude plastic.
   B. As the plastic is being extruded twist the extrudent to a diameter necessary to enter the sizing die and the vacuum-cooling tank (the twisting is done by using pliers to grasp the extrudent and twist it.)

3. Stop "run speed" (turn the RPM Dial to zero)

4. Once twisted, cool the plastic twist portion by splashing water on it.

5. Cut-off plastic roughage, that was held by the pliers with the tin snips.

6. Grasp the twisted plastic with pliers and push it through the sizing die.

7. Grasp the plstic by hand inside the tank.

8. Dial "run speed" to "50"

9. Hand pull the plastic through the tank and try to keep a uniform diameter pipe while, NOTE: The plastic tube may collapse at this time, this is expected.

10. Feed the plastic through the exit gasket and into the take-up rollers.

11. Slide the tank forward keeping it tight against the side and front guides.

TASK DETAILING SHEET

ADJUSTING SPEED OF PRODUCTION

1. Check the specifications for the production rate as given on the work order specifications.

2. Using the work specifications, set the RPM dials for the extrudent run speed and the take-up roller speed.
   NOTE: The dials should be adjusted at the same speed to keep an even flow of plastic through the tank.

3. Constantly cut-off extruded plastic, with tin snips, exiting the rollers.

4. Check and correct for build-ups of plastic at the sizing die. This can be done by either increasing the RPM of the rollers or decreasing the RPM of the extrudent plastic output.

TASK DETAILING SHEET

DEVELOPING THE TUBING

1. Place the lid on the vacuum-cooling tank

    A. Use four wing nuts to fasten the lid-one on each corner stud
    B. Fasten nuts snug-tight

2. Open "water-in" valve to fill tank with cooling water.

3. Turn "water-in" valve off when water reaches the maximum water level mark.

4. Turn off sizing die water valve off, hand tight.

5. Turn cooling tank vacuum adjustment clockwise to obtain maximum vacuum.

6. As pipe blows up, the exit gasket-to-pipe seal is developed, and the tank vacuum rapidly increases.

7. Turn vacuum adjustment counterclockwise to adjust the vacuum according to the production job sheet.

TASK DETAILING SHEET

MAINTAINING PRODUCTION AND QUALITY CONTROL

1. Check and fill the feed hopper with plastic raw material.

2. Tubing at this time is now properly extruding as per the production job sheet.

3. Preliminary check of the operation

   A. RPM Adjustments
   B. Stretching of the Plastic
   C. Visual Appearence
   D. Slippage of the take-up rollers
   E. Collaspsing of the Tubing
   F. Consistent Pressure of Vacuum
   G. Temperature Indicators for Constant Heating Temperatures

   NOTE: Observe extruder screw RPM and motor amperage for a constant, even extrudent output and to check the load on the screw drive motor.
   Increase of amperage indicates an increase of lead on the motor. Possible cause of the plastic not melting in zones one and two, remedy by increasing the temperatures in zones one and two.

   NOTE: Constant checking is required to prevent a build-up of plastic at the entrance to the sizing die.

4. Sampling of the Tubing

   A. Cut-off appromixately 8 inches of tubing from the extruder with the tin snips.
   B. Observe visual qualities of the sample
      1. Smoothness
      2. Ripples
      3. Streaks
      4. Bubbles
      5. Melt
      6. Blow-outs
   C. If not meeting visual qualities adjust the extruder controls as per criteria chart.
   D. Square-off ends of tube sample
      1. Clamp tube in cut-off saw vise
      2. Turn on power-push button
      3. Slowly feed saw into the tubing and cut-off end
      4. Remove the tube from the vise
      5. Repeat the cut-off operation on the other end of the tube
      6. Turn off power-push power off button
      7. Trim off edges of both ends with knife
   E. Outside Diameter Check
      1. Insert tube in outside diameter test device
      2. Rotate the tube
      3. Read the dial indicator at several intervals with hand removed.
      4. Indicate the maximum positive and negative indices

5. Accept or reject tubing according to the specifications, on the job sheet, within the tolerances.

F. Wall Thickness and Concentricity Test
   1. Insert tube in test device
   2. Apply downward pressure on tube with thumb
   3. Rotate tube
   4. Read the dial indicator indices while rotating the tube
   5. Indicate the maximum positive and negative indices
   6. Accept or reject tubing according to the specifications, on the job sheet, within the tolerances

G. Plan for and Adjust Extruder Controls
   1. By using the trouble shooting chart correct extruder controls that will result in quality tubing based on sample test results.

5. Repeat sampling procedure until pipe meets job standards.

6. Material take-off of standard tubing

   A. Cut pipe with snips in 3 foot, 6 inch lengths
   B. Cut off 3 inches from each end
   C. Trim ends free of plastic burrs
   D. Bundle, tape, and tag all tubing (good and bad) for each hour or production.

TASK DETAILING SHEET

SHUTTING-DOWN THE JOB

1. Stop extrusion of plastic by turning the extrudent screw RPM dial to zero.
2. Placing screw drive motor switch to the off position.
3. Allow rollers to pull the remaining pipe through the cooling tank.
4. Stop the take-up rollers by turning the take-up speed dial to zero, and placing the roller on-off switch to the off position.
5. Turn off the vacuum pump by placing the pump switch in the off position.
6. Allow the water in the vacuum-cooling tank to drain out.
7. Turn the heating zone dials to the zero position.
8. Place heating zone power switches to the off position.
9. Allow cooling water to remain circulating through the extruder for 10 minutes.
10. Place the main electrical power switch to the off position.
11. Clean-up
    - A. cut-off excess
    - B. water and pellets
    - C. other

EQUIPMENT

The extrusion machine and related equipment are safe equipment to operate. Minimum care is required to insure safe operating of the equipment by the operator.

EXPOSED DANGERS

The Extruder Heating Bands in some areas of the extruder are exposed. In other areas, around the barrel, the heating bands are guarded. These heating bands reach temperatures of up to 400°F. It is imperative that the heating bands and guards are not touched.

The Extruded Plastic is heated to a temperature of up to 400°F. The plastic at this time is hot and sticky. It is important that in the threading operation the operator uses the proper tools in handling the plastic. The operator must also have wet hands to keep the plastic from sticking-to and causing a burn.

The Cut off Saw has no guards to cover the exposed blade. It is important therefore, for the operator to operate the saw using the appropriate handles. The operator must not allow the blade to come in contact with the operator's hands.

LOCATION OF SAFETY EQUIPMENT

A Fire Extinguisher is located on the wall directly behind the work bench. The operator must keep this area clean and clutter free for fast emergency access. To operate this fire extinguisher:

1. Aim the nozzle at the base of the fire.
2. Pull off the safety pin and safety wire.
3. Squeeze the handle/trigger to release extinguisher.

The operators must be aware of Power Shut-Offs in the case of emergency.

The shut-off for the Extrusion Machine is a red handle switch on the power box. By pushing this red handle down, it cuts-off all electrical power to the extrusion machine. The control box is located at the bottom left front of the extruder.

The Cut-Off Saw main power shut-off switch is the red button on the red power box. The power box is located at the top of the saw.

The Vacuum Pump shut-off is located at the pump mounted to the base board. The pump is located on the top left corner of the work bench. Be familiar with the location of the vacuum pumt shut-off switch since the vacuum-cooling tank may over fill with water and the water will be pumped out of the tank, into the pump, and on to the floor. This will cause serious damage to the vacuum pump.

Introduction-overview Lesson Plan

1. Training Objectives - the trainee will:

   A. Know the name of his foreman and his trainer
   B. Know the job title for which he is being trained and the location of machine(s) he will ultimately operate
   C. List the seven major stages of the extruder operator job
   D. List the variables of heat, pressure, and speed that are involved in the extrusion process
   E. Be able to identify the major parts of the extruder

2. Set-up needs:

   A. Classroom or quite area with table and chair
   B. Audio cassette playback unit
   C. Pencil and paper
   D. Trainee notebook
   E. "Extruder Operator" (Programmed instruction)

3. Instruction Guide:

   A. Introductions
      1. Trainer and trainee exchange names
      2. Trainer walks trainee on to floor giving trainee name of jobs and views extruder in operation and return to classroom — 5 minutes
   B. Trainer and trainee review objectives of the job introduction
   C. Trainee given manual:
      Records names of trainer, foreman and job title
   D. Trainer shows trainee how to operate cassette and then starts extruder operator program — 13 minutes
   E. Trainer asks trainee if he has any questions and answers — 2 minutes

20 min. Total

TRAINEE'S NAME ____________________

JOB TITLE ____________________

FOREMAN ____________________

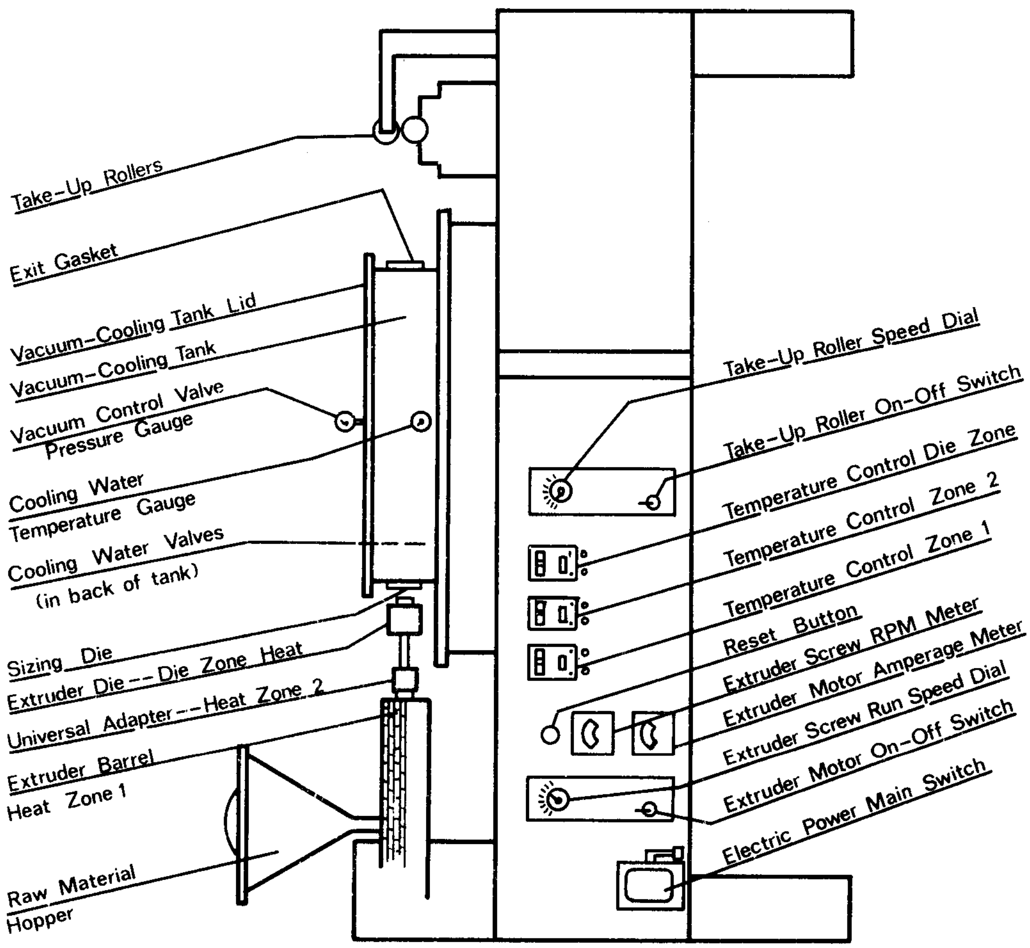
FOUR IMPORTANT MANUFACTURING STAGES

1. ____________________
2. ____________________
3. ____________________
4. ____________________

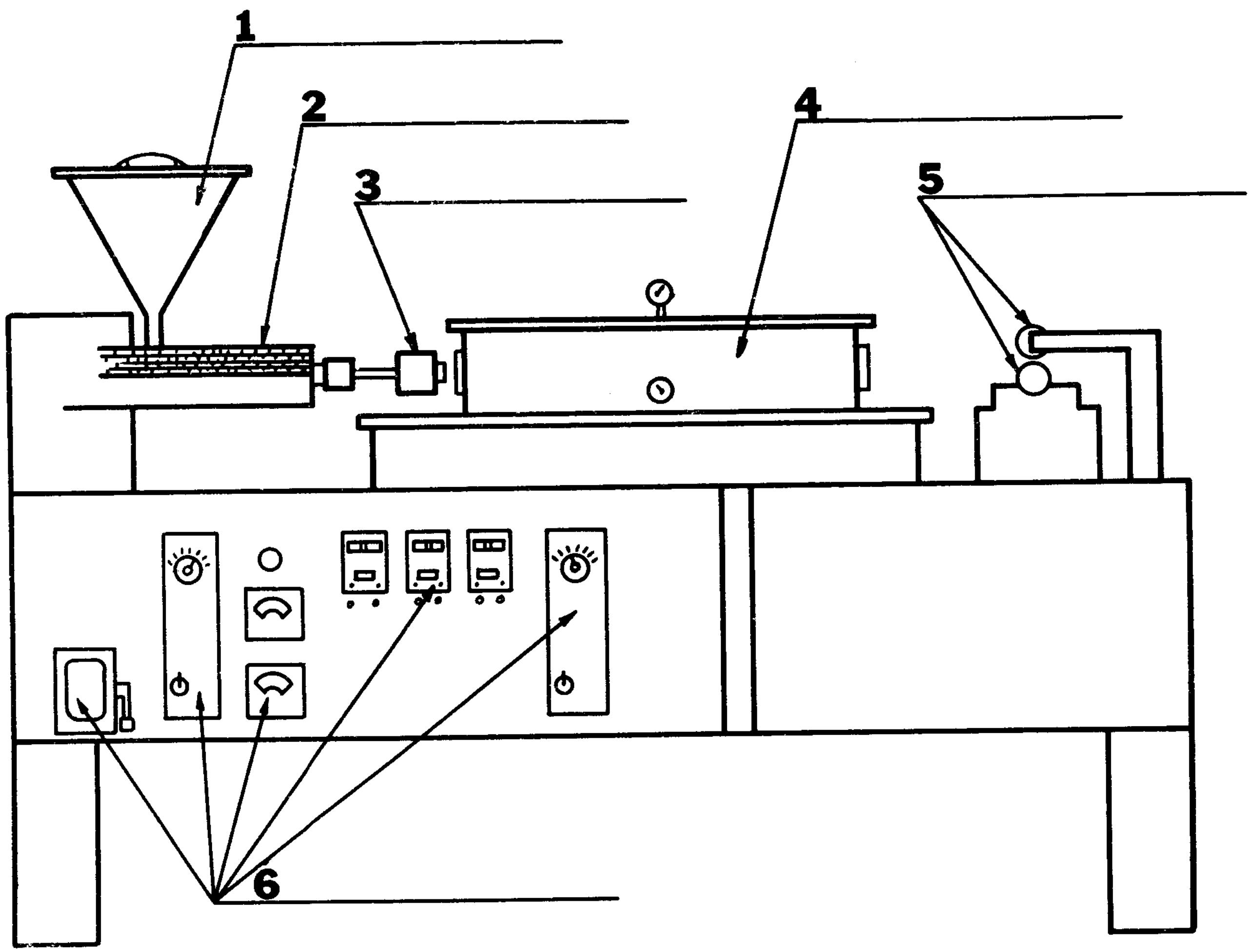
SEVEN MAJOR STAGES OF THE JOB

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________

PLASTIC EXTRUDER PARTS BREAKDOWN



MAJOR PARTS OF THE EXTRUDER



B. SPECIFIC JOB TRAINING - "TALKING PHASE"

1. STAGE 1 - PREPARATION
   A. Training Objectives - The trainee will:
      1. be able to accurately talk through all preparation procedures using a "preparation check-sheet"
      2. be able to identify the product and/or extruder variables that correspond to the specifications listed on the "work order specifications"

   B. Set-Up Needs:
      1. Extruder (no interference with on-going production)
      2. Trainee Manual (preparation check sheet)
      3. Tool Crib Open
      4. Hand Tools
      5. Work Specification Sheet
      6. Pencil

   C. Instruction Guide:
      1. Trainer talks thru preparation procedures while trainee fills in his selected information on his preparation check sheet.
      2. Trainee verbally goes thru the preparation check-sheet for the trainer.
      3. Trainee draws lines from "work order specifications" sheet items to corresponding product and/or extruder variables.

STAGE 1 -PREPARATION

CHECK SHEET

The Extruder	NOTES
______ 1. Extruder Die - tight and clean	______
______ 2. Sizing Die - clean and smooth surface	______
______ 3. Vacuum - Cooling Tank- position and connections	______
______ 4. Tank Exit Gasket - smooth	______
______ 5. Vacuum-Cooling Tank - close drain valve	______
______ 6. Electrical Power - cables connected extruder and cut-off saw	______
______ 7. Vacuum Pump - electrial and air	______
______ 8. Raw Material Hopper - at least half full	______
______ 9. Clean- No water or pellers	"No pellets on heating bands"

Hand Tools

______ 1. Pliers - on extruder bed ______

______ 2. Tin Snips - on extruder bed ______

______ 3. Knife - near cut-off saw ______

______ 4. Rubber Bands - on work bench ______

______ 5. Bundling Cards - on work bench ______

______ 6. Pencil - on work bench ______

______ 7. Rag ______

Pipe Test Device

______ 1. Test Device - on work bench ______

Work Order Specifications ______

______ 1. Read - is it complete ______

______ Next ....Stage 2 - Start-Up

WORK ORDER SPECIFICATIONS

DATE: ____________________
APPROVED BY: ______________

PRODUCT: ____________________

TEMPERATURE SETTINGS:
ZONE 1 ____________________
ZONE 2 ____________________
DIE ZONE ____________________
RUN SPEED: ____________________

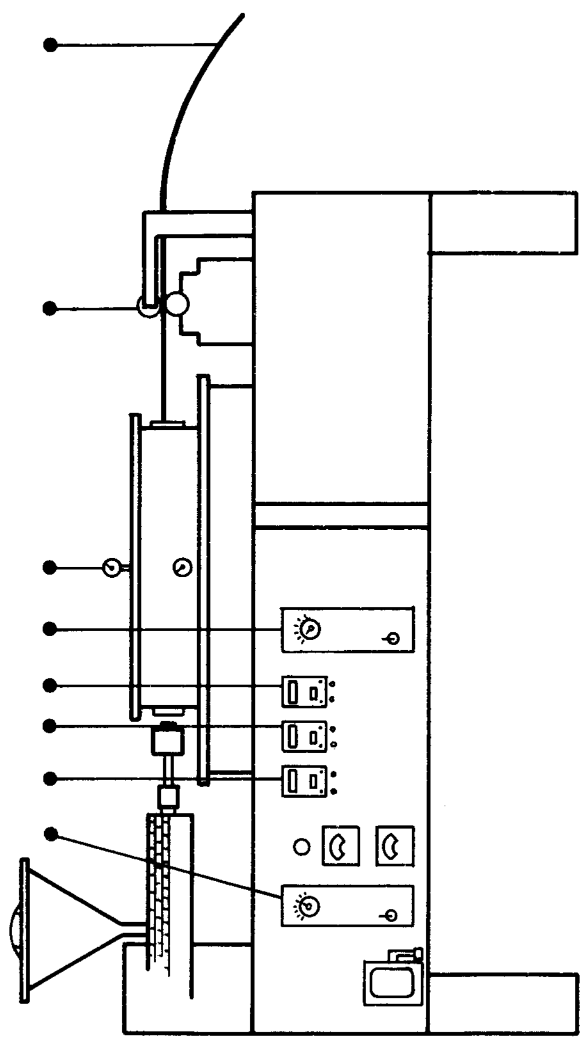
TAKE OFF ROLLER SPEED: ____________________

PRODUCTION RATE: ____________________

NOTES:

QUALITY CONTROL: ____________________
OUTSIDE DIAMETER ____________________
INSIDE DIAMETER ____________________

VACUUM: ____________________



2. STAGE 2 - START-UP

A. Start-Up Objectives - The trainee will:
1. be able to accurately talk through all start-up procedures using a "start-up check sheet" (Appendix D).
2. be able to list one potential caution in the start-up stage.

B. Set-Up Needs:
1. Extruder (no interference with on-going production)
2. Trainee Manual (start-up check sheet)
3. Pencil

C. Instruction Guide:
1. Trainer talks thru start-up procedures while trainee fills in selected information on his start-up check sheet.
2. Trainer emphasizes cautions that are listed on trainer start-up check sheet.
3. Trainee verbally goes thru the start-up check sheet.
4. Trainer has trainee write on his start-up check sheet.

STAGE 2 - START-UP

CHECK SHEET

	Notes
<u>Turn On Utilities</u>	
______ 1. Cooling Water Main Valve Open 1 Full Turn	______
______ 2. <u>Main Power "ON"</u>	______
______ a. All Switches Off and Dials Set To "O" Position	______
______ b. Main Power "ON"	
______ c. Push Green Reset Button	______
______ 3. Temperature Zones "ON" (15 minute warm-up)"	______
______ a. Zone 1 (barrel)	"Caution: No run speed until zones reach temp."
______ b. Zone 2 (universal adapter)	
______ c. Die Zone (extruder die)	______
<u>Levels Of Utilities</u>	______
______ 1. Vacuum-Cooling Tank Filled To Level	______
______ 2. Stop and Wait	______
______ 3. Temperature Zones "ON" Temperature (see work order specifications)	______
______ a. Zone 1 (barrel)	______
______ b. Zone 2 (universal adapter)	______
______ c. Die Zone (extruder die)	______
<u>Start</u>	
______ 1. Run Speed Switch To "START" Position	______
______ 2. Take-Up Roller Switch To "START"	______
______ 3. Take-Up Roller Speed Dial to "42"	______
______ 4. Vacuum Pump Turned "ON"	______

Next .... Stage 3 - Threading

A. Cut-Off Saw

1. power connections
2. on-off switch
3. cutting stroke - trainer gets a piece of tubing, clamps the tubing in the vise and cuts through the tubing. the trainer explains the cutting pressure, speed and safety. the trainee now procedes to practice the cutting of tubing.

B. Test Device

1. the trainer takes the cut tubing and cleans off the burrs with the knife. the trainer explains why burrs must be removed.
2. the trainer explains the principle of the test device.
3. the trainer demonstrates the testing procedures. the trainer notes the hand movements and coordination to recieve a correct reading.

   NOTE: It is imperative that readings be made with the operator's hands removed from the tubing. The operators's hands holding the tubing will give untrue readings. This is because a person's hands are never steady enough for the indicator to record a consistent measurement.

4. the trainee now takes the tubing he has cut and practices the testing procedures.

C. Extrusion Machine

The trainer demonstrates and explains the functions of the equipment below. The trainee practices the operating of the equipment once the trainee has returned correct answers to the trainer's questions regarding the equipment.

1. cooling water
2. power switches
3. vacuum pump and pressure adjustment valve
4. temperature controllers
5. raw materials
6. run speed control
7. extrusion die
8. extrusion screw
9. sizing die
10. vacuum-cooling tank
11. take-off roller speed control

3. STAGE 3 - THREADING

A. Threading objectives - The trainee will:
  1. be able to accurately talk through all threading procedures using a "threading check sheet" (Appendix E).
  2. be able to list four potential problems in the threading stage.

B. Set-Up Needs:
  1. Extruder (no interference with on-going production)
  2. Trainee Manual (threading check sheet)
  3. Pencil
  4. Threading Training Aid

C. Instruction Guide:
  1. Trainer emphasizes that threading requires close attention
  2. Trainer talks through threading procedures while trainee follows both the Training Aid and the check sheet.
  3. Trainer emphasizes cautions and trainee records these on his threading check sheet.
  4. Trainee talks through the threading procedures using the check sheet and job aid.

CHECK SHEET

		Step	NOTES
_____	1.	Sizing Die Coolant Valve Open 4 Turns	
_____	2.	Start Extruding Run Speed "50"	
_____	3.	Twist Extrudant	
	_____ a.	Twist In Taper With Pliers	
	_____ b.	Stop Run Speed	
	_____ c.	Cool End "2"	
	_____ d.	Cut-Off Tip	Plastic hot & sticky keep hands wet.
_____	4.	Threading	
	_____ a.	Push Extrudant Through Sizing Die	
	_____ b.	Hold Plastic Inside Tankd and Dial Run Speed To "50"	
	_____ c.	Steadily Hand Pull Plastic Through Tank	Tube collasped- don't worry!
	_____ d.	Feed Plastic Through Exit Gasket and Into Take-Up Rollers Steadily	Watch sizing die for clogging.
_____	5.	Slowly Slide Tank Forward on Guides	Watch sizing die for clogging.
_____	6.	Adjust tank location	Watch rollers! ! Make sure they are pulling out the plastic.

Next .... Stage 4 - Adjusting Speed

THREADING TRAINING AID

(3 Dimensional with Actual Plastic Extrudant)

THREADING THE EXTRUDER

1. 

Extruder off

2. 

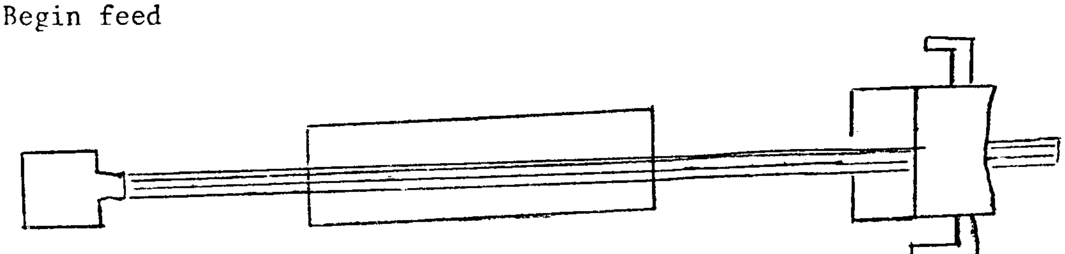
Extruder on

3. 

Extrudant twisted

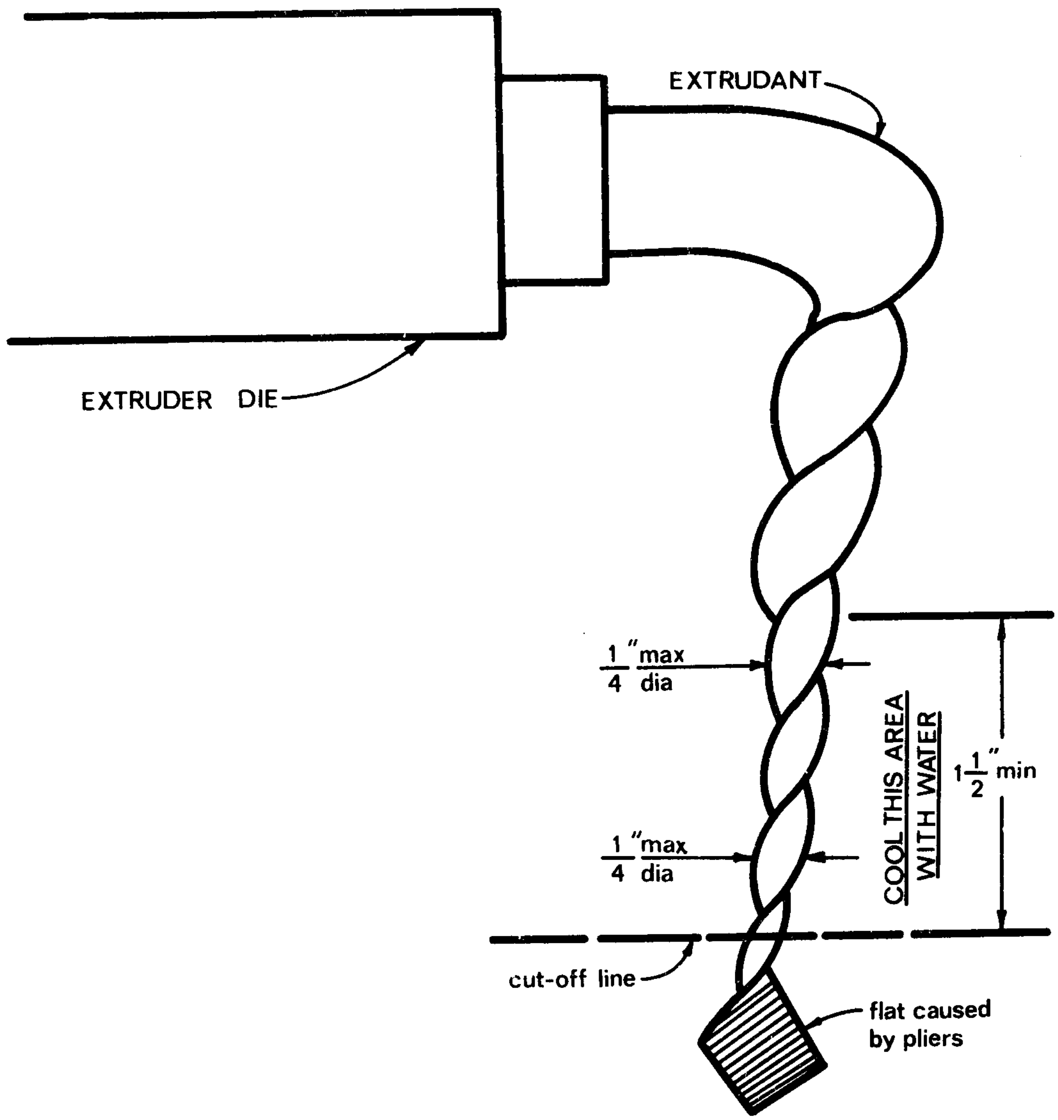
4. 

Begin feed

5. 

Take-up rollers

DIAGRAM A


EXTRUDANT
EXTRUDER DIE
1/4 "max dia
1/4 "max dia
COOL THIS AREA WITH WATER
1 1/2 " min
cut-off line
flat caused by pliers

4. STAGE 4 - ADJUSTING SPEED

A. Speed Adjusting Objectives - The trainee will:
1. be able to accurately talk through all speed adjusting procedures using an "adjusting speed check sheet" (Appendix F).
2. be able to list two potential problems in the adjusting speed stage.

B. Set-up Needs:
1. Extruder (no interference with on-going production)
2. Trainee Manual (adjusting speed check sheet)
3. Pencil
4. Adjusting Speed Training Aid

C. Instruction Guide:
1. Trainer has trainee determine the production rate and roller speeds from specification sheet.
2. Trainer talks thru adjusting speed check sheet and shows training aid samples of extrudant with inappropriate settings.
3. Notes and cautions are emphasized and trainee enters these in his manual.
4. Trainee verbally goes thru adjusting speed procedures and points out the two cautions.

CHECK SHEET

			NOTES
______	1.	Get "Work Order Specifications"	
______	2.	Set Run Speed And Take-Up Roller Speed	Adjust both at same time
______	3.	Keep Cutting Off Exiting Plastic	
______	4.	Check For Jamming At Sizing Die	
______	5.	Adjust Tank Location	

Next .... Stage 5 - Developing Tubing

WORK ORDER SPECIFICATIONS

date: ____________
approved by: ________________

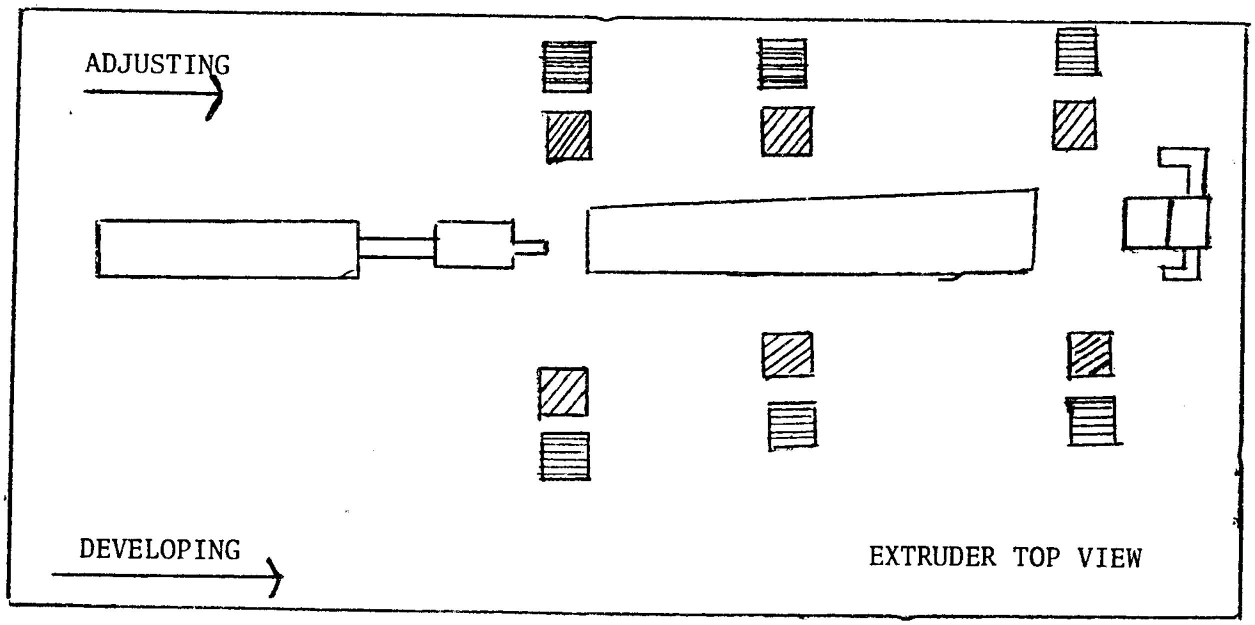
PRODUCT:	POLYPRO PIPE
TEMPERATURE SETTINGS:	
Zone 1	380°
Zone 2	380°
Die Zone	380°
Run Speed	90RPM
TAKE OFF ROLLER SPEED:	40-50 (varies)
PRODUCTION RATE:	50 Lengths/Hour

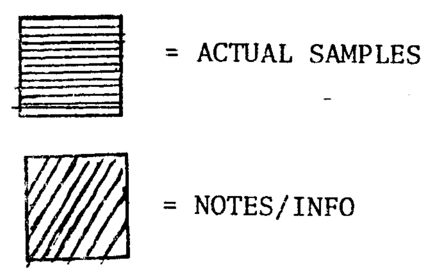
notes:

QUALITY CONTROL:	± .010
outside diameter	3/8"
inside diameter	.302
VACUUM:	4-5 P.S.I.

ADJUSTING SPEED AND DEVELOPING TRAINING AID

Chart With Actual Extrudant Samples On
Drawing Of Extruder 12" X 24" Approx.





5. STAGE 5 - DEVELOPING

A. Developing Pipe Objectives - The trainee will:
1. be able to accurately talk through all developing pipe procedures using a "developing pipe check sheet" (Appendix G).
2. be able to list three potential problems in the developing pipe stage.

B. Set-Up Needs:
1. Extruder (no interference with on-going production)
2. Trainee Manual (developing pipe check sheet)
3. Pencil
4. Developing Pipe Training Aid

C. Instruction Guide:
1. Trainer talks thru the developing check sheet being careful to point out all controls.
2. Trainer emphasizes cautions and shows the trainee tubing samples from the developing tubing training aid and trainee enters cautions in his manual
3. Trainee talks thru the developing stage and points out the three cautions using the check sheet and job aid.

STAGE 5 - DEVELOPING

CHECK SHEET	NOTES
1. Vacuum - Cooling Tank	
_____ a. Lid on	Watch for lid warpage
_____ b. 6 Wing Nuts	
_____ c. Snug-Tight Wing Nuts CAREFULLY	
2. Water	
_____ a. Open Water-In Valve/Turn Off Die Coolant Water Valve	No Overfill!!
_____ b. Check Sizing Die Seal - Sealed When No Water Comes Out of Die.	
_____ c. Turn Off Water-In Valve When Water Reaches Maximum Water Level	All Valves Closed.
_____ 3. Push Down On Tank Lid	Push Down on Lid
4. Vacuum	
_____ a. Turn Completely Clockwise (↻) Vacuum Adjustment Screw (located at cooling tank)	Look for Balloning
_____ b. Adjust Vacuum Pressure To A Maximum Of 5 On Dial	
_____ c. When Exit Gasket Seals Re-Adjust Vacuum To 5 On The Dial By Turning Adjustment Screw Counter-Clockwise (↺)	

_____ 5. Important Watch Plastic Jam/Increase Rollers Speed

Next .... Stage 6 - Production and Quality Control

6. STAGE 6 - PRODUCTION AND QUALITY CONTROL

A. Production and Quality Control Objectives - The trainee will:
   1. be able to accurately talk through all production and quality control preliminary check items using the "production and quality control check sheet" (Appendix H).
   2. be able to list two potential problems in the production and quality control preliminary check items.
   3. be able to talk through all material take-off procedures with no aids.
   4. be able to remove a sample of pipe from the extruder (while in production) and to accurately critique the pipe according to visual quality specifications.
   5. be able to accurately test pipe on outside diameter tolerances.
   6. be able to accurately test pipe on wall thickness and eccentricity tolerances.
   7. be able to select appropriate extruder adjustments given reject pipe samples.

B. Set-Up Needs:
   1. Extruder (no interference with on-going production)
   2. Trainee Manual (production and quality control check sheet)
   3. Pencil
   4. Tin Snips
   5. Pipe Cut-Off Saw
   6. Pipe Diameter Tester
   7. Pipe Wall Thickness Tester
   8. Pipe Problems Aid

C. Instruction Guide:
   1. Trainer talks thru all production maintenance procedures using the check sheet and points out two cautions.
   2. Trainee talks thru the above using check sheet.
   3. Trainee demonstrates material take-off procedures and visual check procedures using the training aid and then has the trainee execute take-off and visual check.
   4. Using the check sheet and pipe sample aid, the trainer demonstrates the outside diameter test and then has the trainee do the same with the check sheet only.
   5. Using the check sheet and pipe sample aid, the trainer demonstrates the wall thickness and eccentricity test and then has the trainee do the same with the check sheet only.
   6. Trainer provides samples and asks the trainee what the problem is and what adjustments need to be made. The trainer makes corrections if the trainee is wrong.

STAGE 6 - PRODUCTION AND QUALITY CONTROL

CHECK SHEET

NOTES

Preliminary Checks

____ 1. Hopper Filled ____________

____ 2. RPM Constant Reading ____________

____ 3. No Stretching of Plastic ____________

____ 4. No Jamming of Plastic ____________

____ 5. Tubing Not Collapsed ____________

____ 6. No Take-Up Roller Slippage ____________

____ 7. Vacuum Pressure Constant ____________

____ 8. Temperature Constant ____________

Pipe Cut-Off And Visual Check

____ 1. Cut-Off 6" Sample Pipe ____________

2. Visual Check ____________

____ a. Smooth ____________

____ b. No Ripples ____________

____ c. No Streaks ____________

____ d. No Bubbles ____________

____ e. No Blow-Outs ____________

____ f. Even Melt ____________

Pipe Dimensional Testing Outside Diameter ____________

____ 1. Insert Pipe Into Test Devise ____________

____ 2. Rotate Pipe ____________

____ 3. Read Maximum Positive and Negative Readings With Hand Removed ____________

____ 4. Compare To Specs - Accept or Reject ____________

____ 5. Select Machine Corrections From Chart (if needed) ____________

			NOTES
		Square-Off Pipe End	
______	1.	Clamp Pipe Sample Into Cut-Off Saw Vise	______
______	2.	Cut-Off Saw Power "ON"	______
______	3.	Feed Saw Slowly	______
______	4.	Power "OFF"	______
______	5.	Remove Pipe	______
______	6.	Trim Pipe End With Knive	______
		Pipe Dimensional Testing **Wall Thickness/Concentricity Test**	______
______	1.	Insert Pipe Into Test Devise	______
______	2.	Assert Downward Pressure With Thumb	______
______	3.	Rotate and Read Maximum Positive And Negative Readings While Rotating Pipe	______
______	4.	Compare To Specs - Accept Or Reject	______
______	5.	Select Machine Corrections From Chart (if needed)	______
		Material Take-Off	______
______	1.	Cut 3' - 0" Minimum Pipe Lengths	______
______	2.	Good Pipe In Bin	______
______	3.	Perform Dimensional Testing Every Fifth (5th) Length Of Pipe	______
______	4.	Bundle On The Hour	______

______ Next..................Stage 7 - Shutting Down

7. STAGE 7 - SHUTTING-DOWN

A. Shut-Down Objectives - The trainee will:
   1. be able to accurately talk through all shut-down procedures using a "shut-down check sheet" (Appendix I).
   2. be able to list one potential problems in the shut-down stage.

B. Set-Up Needs:
   1. Extruder (no interference with on-going production)
   2. Trainee Manual (shut-down check sheet)
   3. Pencil

C. Instruction Guide:
   1. Trainer talks thru shut-down procedure to trainer using the check and emphasizing the one shut-down caution.
   2. Trainee explains shut-down procedure to trainer using the check sheet.

STAGE 7 - SHUTTING DOWN

CHECK SHEET

NOTES

____ 1. Stop Extruder - Dial RPM to "0" and Run Speed Switch "OFF" - Push Tank To Right

____ 2. Rollers Pull Remaining Pipe Thru Tank

____ 3. Stop Take-Up Rollers - Roller Speed Dial To "0" and Switch "OFF"

____ 4. Vacuum Pump Switch "OFF"

____ 5. Open Drain Valve On Vacuum-Cooling Tank

____ 6. Set Heating Zone Dials to "0" and Place Heating Zone Power Switches To "OFF"

____ 7. Remove Tank Lid - Place Lid Over Drain

____ 8. Keep Water Main Valve Open

____ 9. Extruder Main Power Switch "OFF"

____ 10. Pull All Power Cords From Sockets Wrap Cords Around Equipment

____ 11. Final Bundling

____ 12. Put Tools and Items Into Tool Box

____ 13. Clean-Up

- ____ a. Cut-Off Excess
- ____ b. Extruder Die
- ____ c. Water and Pellets
- ____ d. Work Bench
- ____ e. Other

____ 14. Lock Tool Box

EXTRUSION MACHINE TROUBLESHOOTING

The following are conditions varied from normal that have an effect on the quality and production of tubing.

TEMPERATURE TO HIGH

Accessive heating of the plastic will liquify the plastic to a point that the plastic will become runny (watery). Plastic in this state will make it easier for the take-off rollers to pull the plastic. The take-off rollers will increase in speed, stretch the tubing resulting, in a reduction of the outside diameter, vacuum loss, and, if not corrected in time, halt production.

TEMPERATURE TO LOW

The extruder uses heat to melt the raw material, plastic pellets. When there is insufficient heat to melt and mix the raw material the plastic will melt partially. The result is plastic tubing with a crystallized texture and appearance.

VACUUM TO HIGH

The standard vacuum setting is 5 inches of mercury. Vacuum above 5 will expand the tubing to a larger outside and inside diameter.

VACUUM TO LOW

Vacuum pressure below 5 will not be sufficient to expand the tubing to the standard outside and inside diameter. The diameters will be smaller.

ROLLER SPEED TO FAST

Any variance in roller speed will result in serious production difficulties. If the roller speed is increased it will stretch the tubing. This stretching will result in a decreased wall thickeness and an increased outside diameter since there is less plastic restricting the vacuum to expand the tubing. The speed may increase to the point of stretching the tube to a very small diameter thus causing a loss in vacuum, production, and the process will have to be rethreaded.

ROLLER SPEED TO SLOW

Roller speed at a slower than normal rate will result in plastic not being pulled out of the vacuum-cooling tank at a rate proportional to the plastic being extruded into the vacuum-cooling tank to obtain quality tubing. This condition results in more plastic pushed into the sizing die. This will cause the wall thickness to increase and if this condition is not corrected the plastic will jam and clog the sizing die. This will shut-down production and the process must be restarted. Jamming of plastic into the sizing die will damage the die if the plastic solidifies inside the sizing die.

RUN SPEED TO FAST

The run speed controls the amount of plastic extruded into the sizing die. If the plastic is being extruded faster than it is pulled out by the take-off rollers, the plastic will jam and clog the sizing die. An increase in run speed will cause the tube wall thickness to increase. The inside diameter will decrease. The outside diameter may decrease since the wall thickness increase causes added restriction for the existing vacuum pressure to expand the tubing.

RUN SPEED TO SLOW

A slower run speed will cause less plastic to be extruded. When the take-off speed is not reduced the rollers will have less plastic to pull out. The results in a thinner wall thickness. If not corrected the wall thick-ness will become increasing thinner and the tubing will become smaller. This will cause a loss in vacuum from not enough plastic sealing the sizing die causing production to stop.

TEMPERATURE CONTROLLER

TEMPERATURE CONTROLLER - Correct Indications

Feedback indicator reads LOW and load light is ON

Feedback indicator reads HIGH and load light is OFF

Feedback indicator reads ON TEMP and load light FLICKERS

TEMPERATURE CONTROLLER - Malfunction Indications

Indicator Readings	Load Light	Treatment
ON TEMP	bright load light	dial temperature setting lower until load light is off
HIGH	bright load light	dial temperature setting lower until load light is off.
LOW	load light is off	dial temperature setting higher until load light comes on.

TAKE-OFF ROLLERS

Dial Setting	Speed Variance	Treatment
unchanged	speed increases	set control to a lower speed
unchanged	speed decreases	set control dial to a higher speed.

RUN SPEED

Dial Setting	Speed Variance	Treatment
unchanged	speed increases	set control dial to a lower speed
unchanged	speed decreases	set control dial to a higher speed.

CAUTION: The take-off rollers and run speed dials are sensitive to the operator's touch.
DO NOT OVER-REACT - A touch on the dial will cause the necessary change is speeds to correct the malfunction.

EXTRUSION PRINCIPLES

1. ______________________

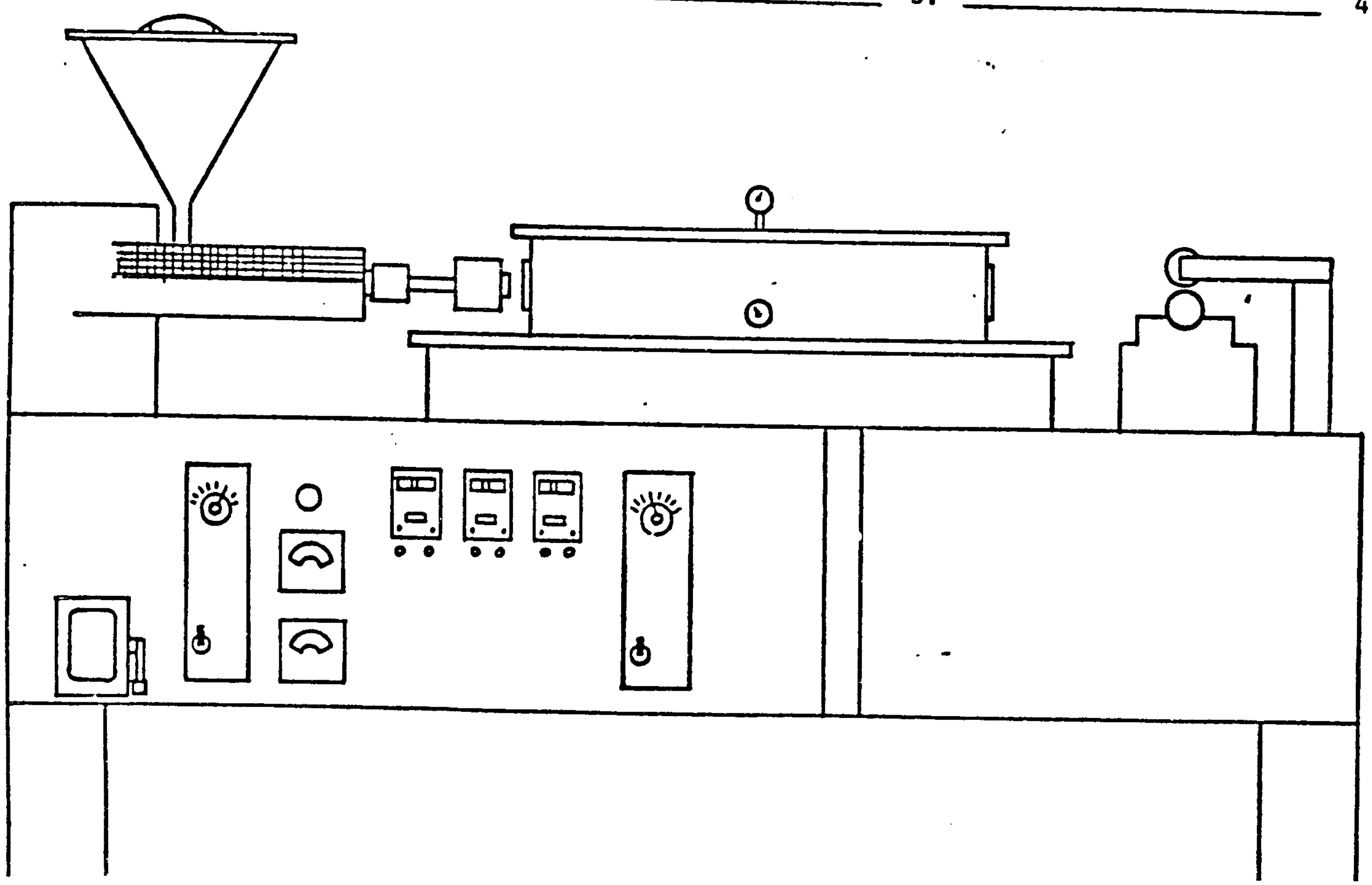
2. ______________________

3. ______________________

4. ______________________

WHY? ______________________

1. ____________ 2. ____________ 3. ____________ 4. ____________

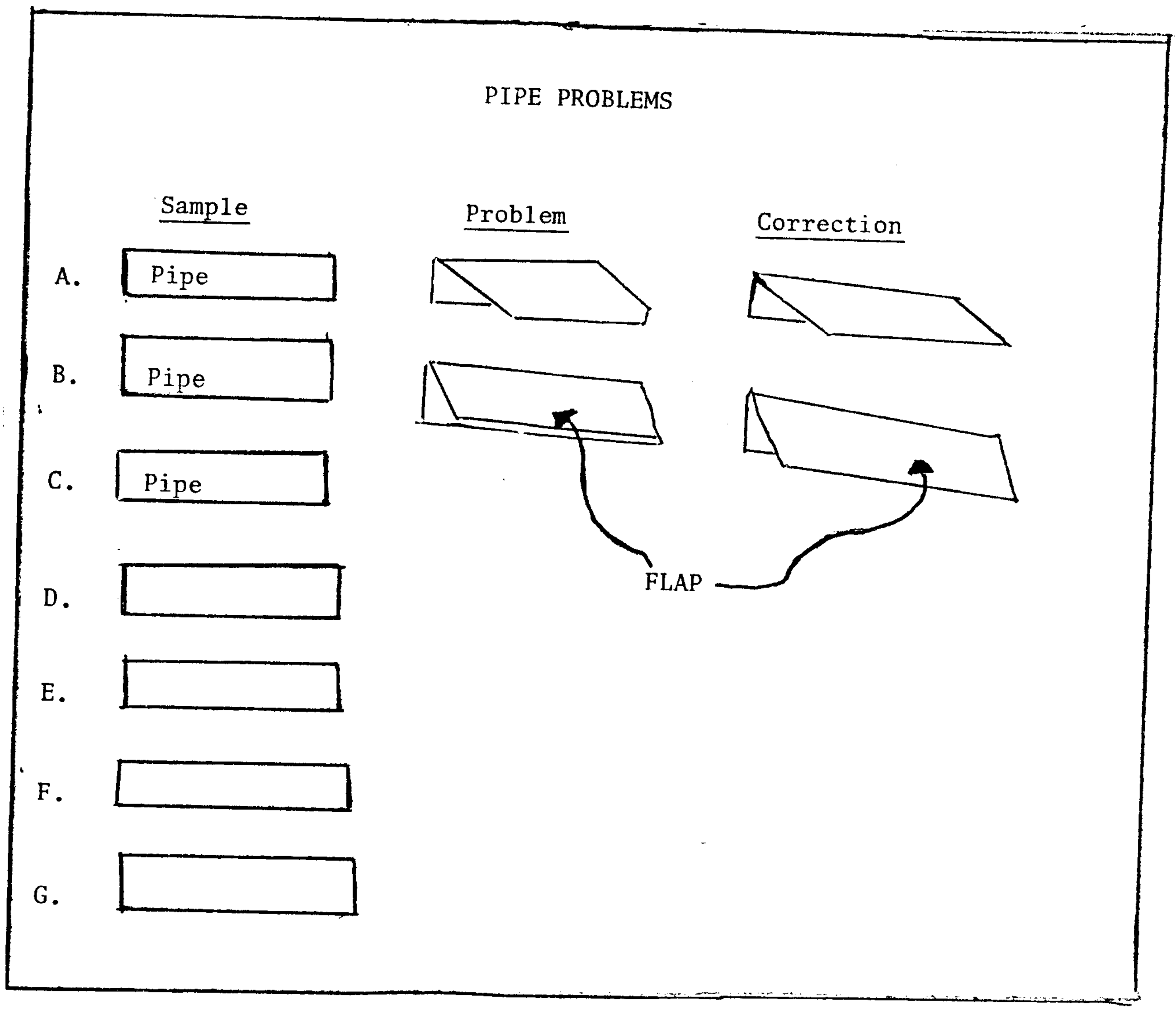


2. Production Problems
   1. Objectives: The trainee will:
      A. Be able to accurately diagnose the production problems causing the six visually detected pipe qualities and to recommend the corrective procedures.
      B. Be able to accurately diagnose the production problems causing over and under wall thickness qualities and to recommend the corrective procedures.
      C. Be able to accurately diagnose the production problems causing over and under wall thinkness and wall concentricity problems and to recommend the corrective procedures.

   2. Set-Up Needs:
      A. Classroom or quite area with table and chair.
      B. Trainee manual and pencil
      C. Chalkboard
      D. Pipe problem training aid.

   3. Instruction guide:
      A. Trainer and trainee review each sample and determine the corrective procedure for each using the "pipe problem training aid."
      B. Trainee is given five minutes to study the aid.
      C. The trainer presents five random samples (one at a time and has the trainee identify the diagrams and list the corrective procedure for each.

TRAINING AID



PROBLEM AND CORRECTION HIDDEN UNDER FLAP!!

THE EFFECTS OF EXTRUDER VARIABLES
ON THE QUALITY AND PRODUCTION OF
EXTRUDING PLASTIC TUBING

TUBING DEFORMITIES AND REQUIRED TROUBLESHOOTING

PRODUCTION OUTPUT

Maximum machine hourly production output - 60
Maximim machine hourly production output - 50

FOUR HOUR JOB SHIFT

Estimated maximum worker hourly production output - 210
Estimated minimum worker hourly production output - 175
Estimated average worker hourly production output - 44

TYPE OF DEFORMITY	MALFUNCTION	EFFECTS OF MALFUNCTION	TREATMENT
Blow-outs	Run speeds or roller speed	Plastic is being streatched to thin thus vacuum presure causes a burst in the tubing wall.	Increase extruder run speed and/or decrease take-up roller speed
Bubbles	Extruder run speed varies	The vacuum is not constant. This causes the tubing to expand or collapse in intervals. The vacuum is lost because the exit gasket or sizing die is not fully sealed.	Reduce the take-up roller speed
Bumps - Ripples	Sizing die-cooling water injected into the die.	Shock Cooling - The rapid cooling by the water sprayed on the plastic causes rapid cooling and bubbling of the plastic caused by gross changes in temperatures. The seal at the sizing die may not be complete thus allowing water into the inside of the die.	Close valve in the water line to the sizing die. If closed increase run speed to increase seal at the sizing die.

CAUTION - The roller speed co. rol dial is very sensitive. A jerk on the dial in Left or right direction may be sufficient to cause the necessary correction.

TYPE OF DEFORMITY	MALFUNCTION	EFFECTS OF MALFUNCTION	TREATMENT
Melt (low)	Heating zone temperatures at low temperature.	With the heating zone blow temperature the plastic is not receiving enough heat to fully melt the plastic pellets but only enough to cause the pellets to stick together and partially melt.	Increase heating zones one and two in intervals of five (5) degrees
Streaks - Ridges	Heating zone temperatures at low temperatures	The plastic is being exruded at to low a temperature thus causing full solidifing to soon before sizing and forming the tubing.	Increase heating zones one and two in intervals of five (5) degrees.
Outside diameter over size	Run speed or roller speed	The wall thickness is thin enough for the vacuum pressure to blow-up the tubing outside of the sizing die in the tank and expanding the tubing beyond the sizing die restrictions	Increase the extruder run speed and/or decrease the take-up roller speed
Out side Diameter under size	Run speed or roller speed	The wall is to thick for the vacuum pressure to expand fully the tubing	Decrease the extruder run speed and/or increase the take-up roller speed
Inside diameter over size	Run speed or roller speed	With the inside diameter over size the wall thickness decreases and may result in blow-outs.	Increase the extruder run speed and/or decrease the take-up roller speed.

TYPE OF DEFORMITY	MALFUNCTION	EFFECTS OF MALFUNCTION	TREATMENT
Inside diameter undersize	Run speed or roller speed	The wall thickness will increase thus not meeting dimensional standards, can also result in under sized outside diameter.	Decrease the extruder run speed and/or increase the take-up roller speed.
Eccentricity of outside diameter to inside diameter	Sizing die and the extruder die out of center	The outside and inside diameters will not be aligned thus causing the tubing to be rejected for dimensional quality. Can cause blow-outs.	Adjust the height and alignment of the extruder die by loosening lock bolts and aligning the centers of the dies. (To be performed by the forman.)
zero (0) vacuum	Tubing does not seal the sizing die, the exit gasket, or the vacuum-tank lid is not fastened, or the vacuum pump is not on	The tubing collapses. The tubing is deformed and undersize	No seal at: 1. Tank lid- push down on the lid by the operator. Either loosen or tighten the lid fastening wing nuts. 2. Sizing Die - decrease the roller speed or increase the run speed. 3. Exit Gasket - seal the sizing die. Push a wit rag into the exit gasket to seal it.
Melt (high)	Heating zone temperatures at high temperature	With the heating zones above temperature the plastic is receiving to much heat. This results in the plastic becoming watery. The pipe will be transparent in color and have ripples in its texture.	Lower heating zones one and two in intervals of five (5) degrees.

PIPE PROBLEM QUIZ

Problem	Corrective Procedure
1. ________________ ________________	1. ________________ ________________ ________________
2. ________________ ________________	2. ________________ ________________ ________________
3. ________________ ________________	3. ________________ ________________ ________________
4. ________________ ________________	4. ________________ ________________ ________________
5. ________________ ________________	5. ________________ ________________ ________________

E. PRODUCTION PROBLEM TRAINING : "DOING"

1. Objectives: the trainee will:
   A. Be able to diagnose and correct for two visually defected pipe imperfecti in less than five minutes each and without losing the flow of plastic.
   B. Be able to diagnose and correct for one wall thickness imperfection in less than five minutes and without losing the flow of plastic.
   C. Be able to diagnose and correct for one wall thickness and/or concentrici imperfection in less than five minutes and without losing the flow of plastic.

2. Set-up needs:
   A. Extruding machine.
   B. Trainee manual and pencil.

3. Instruction guide:
   A. Trainer explains to trainee that he is going to insert production problems into the extruder and then observe the trainee's reactions.
   B. Trainer asks trainee to turn around and then insert the first problem.
   C. Repeat process until all four are done.

PRODUCTION PROBLEM TRAINING

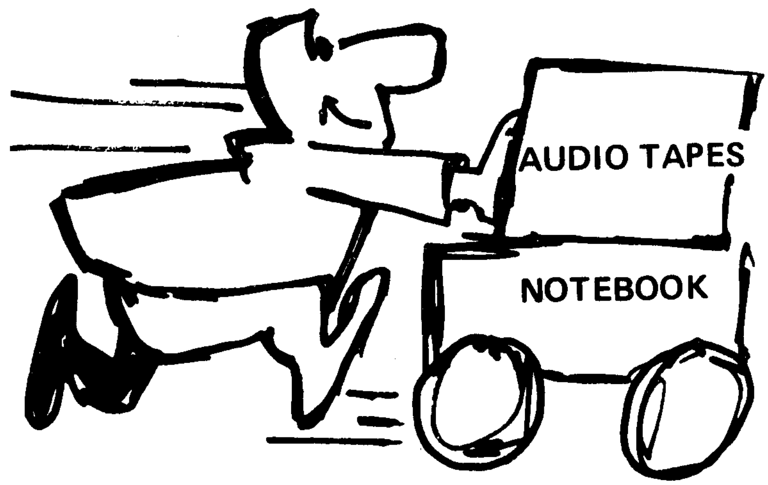
Problem	Machine changes	Trainee reactio[n]
1. Pipe stretches		
2. Wall thickness oversize		
3. Ripples		
4. O.D. under		

Script for the Introduction/Overview
of the Extruder Operator Job

1. The following program will present to you information about the training program in which you will learn the basic information of the extrusion process, the major job tasks, and introduce you to the remaining part of the training program and your trainer. Do not try to remember any details, this program is simply an overview of the job.

2. Your trainer is the individual who will instruct you in the job tasks and their correct performance. He is fully experienced with the equipment and the job responsibilities.
Your Trainer: <u>Steve Sawzin</u>

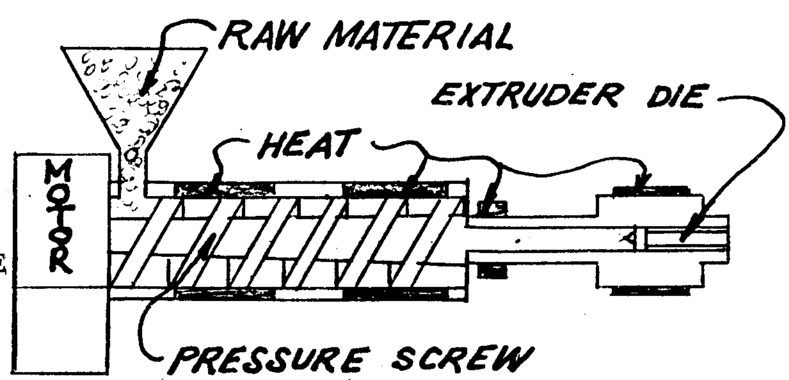
3. You will be presented with a training manual. This manual is yours to use as a guide throughout your employment period. In the manual you will find information on safety, job tasks, troubleshooting guide, and other information



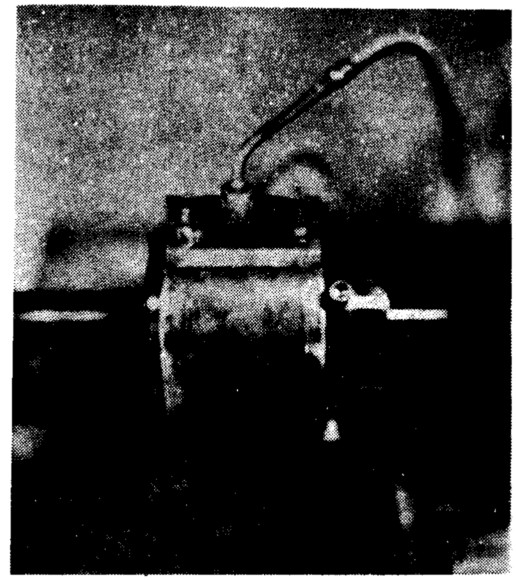
4. The extrusion of plastic tubing has four main manufacturing variables:

1. RAW MATERIALS
2. HEAT AND PRESSURE
3. EXTRUDER DIE
4. VACUUM SIZING

Please write these in your manual.

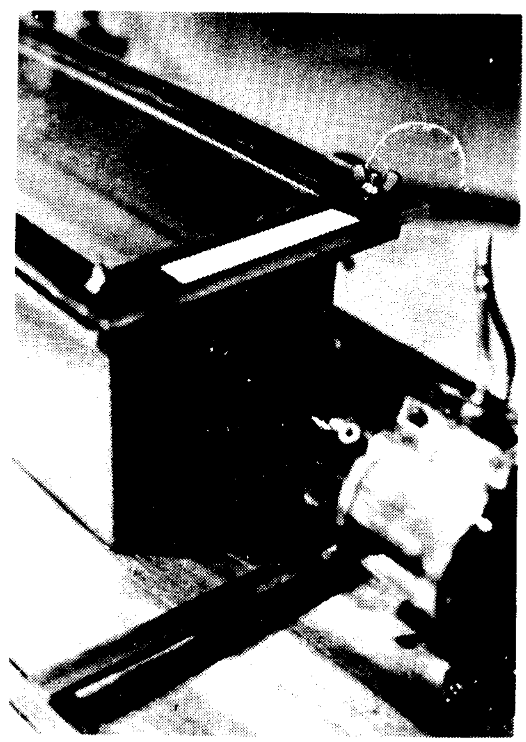


5. The extruder takes raw material, and with pressure, forces the raw material thru a specially shaped hole that is called a die.



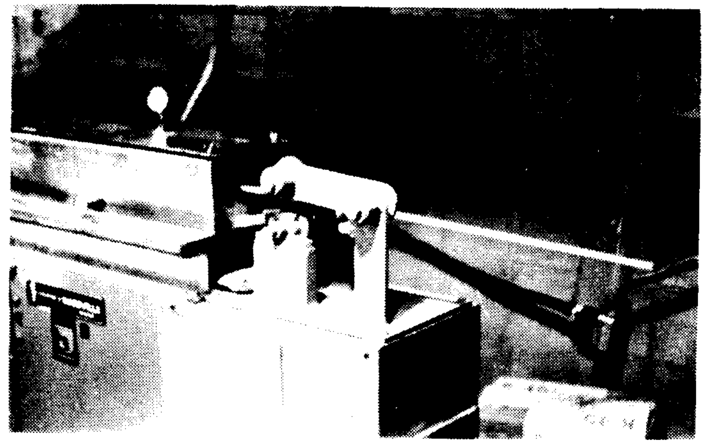
6. In this machine, raw material in the form of pellets is heated and pushed thru an extruder die.

7. The plastic as it leaves the die, called extrudant, is soft and is formed into the shape of a tube.

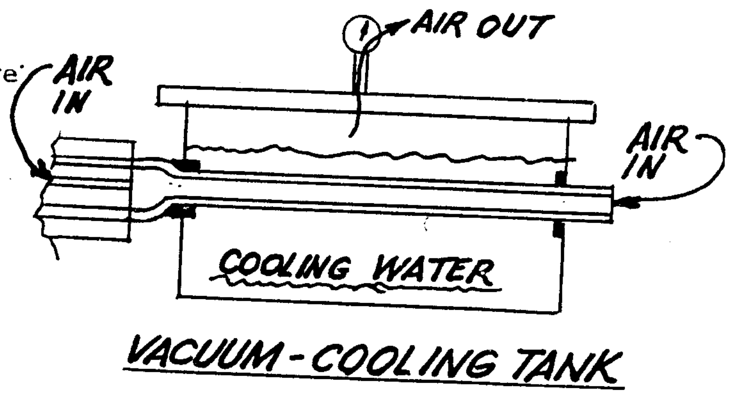


8. This extruded tube then travels into another die, a sizing die. This die forms the soft tubing to a final outside diameter.

9. The tubing then travels thru a vacuum-cooking tank that cools the tubing and blows it up to keep the tube from collapsing. The cooling of the soft plastic tubing is done by water in the tank.

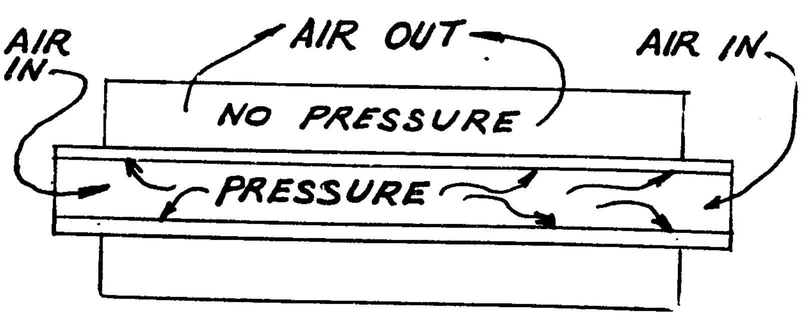


10. The blowing up of the tubing is done by atmospheric pressure on the inside of the tube and the lack of pressure on the outside of the tube in the vacuum-cooling tank.



11. The lack of air on the outside of the tubing in the vacuum-cooling tank is caused by a vacuum pump that pumps air out of the tank.

12. With no atmospheric pressure on the outside of the tube, the atmospheric pressure on the inside of the tube expands the tubing and keeps it from collaspsing while water cools and solidifies the tube to its final dimensions and quality.

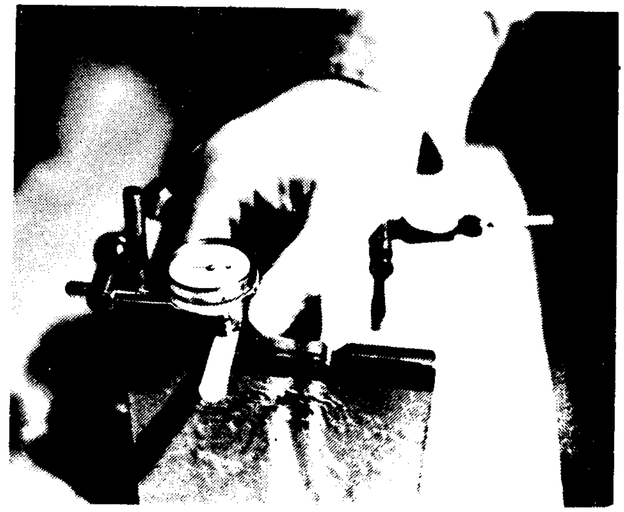


quality.

13. What is a plastic extruder operator? A description of a plastic extruder operator is presented on page (1) in your manual. It describes the general duties and responsibilities of your job.

14. The plastic extruder operator's tasks are many and diversified. The tasks include operating a plastic extrusion machine to produce quality plastic tubing.

15. the quality controlling of the tubing

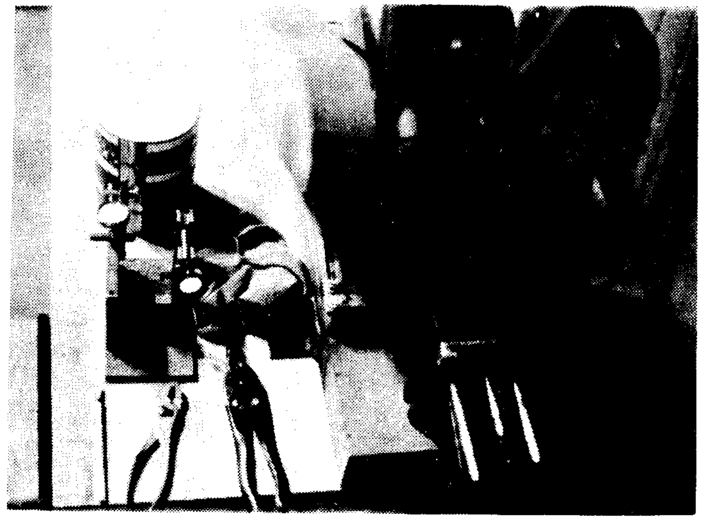


16. gathering and building of the tubing.

17. shut down, and clean up of the job area.

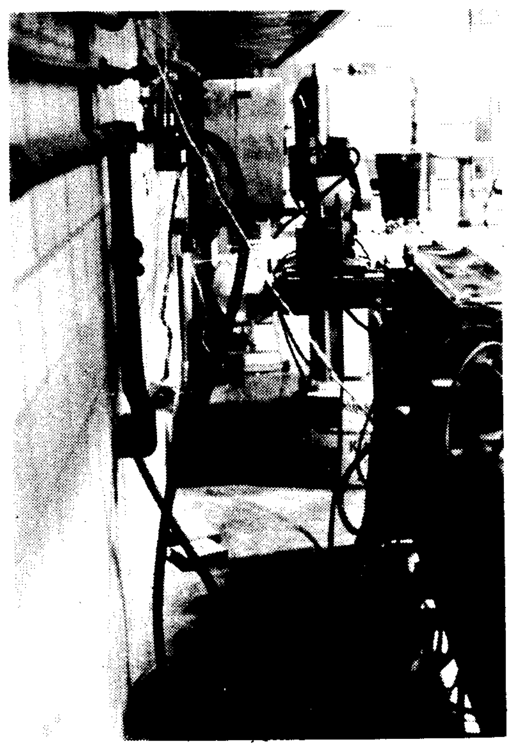
18. There are three main job phases:

___1. BEGINNING PRODUCTION
___2. MAINTAING PRODUCTION
___3. SHUTTING - DOWN PRODUCTION



19. (___1. Beginning Production) To begin production the first job tasks include: checking accessibility of tools

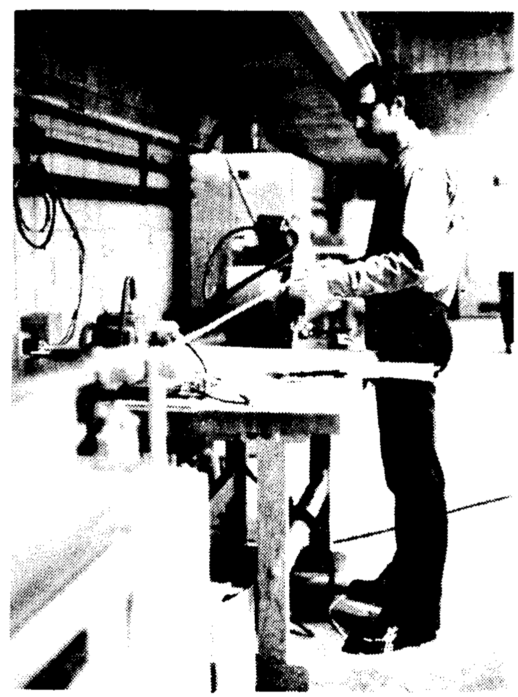
20. Making equipment connection,



21. checking the raw material supply,

22. starting-up of the extrusion machine,

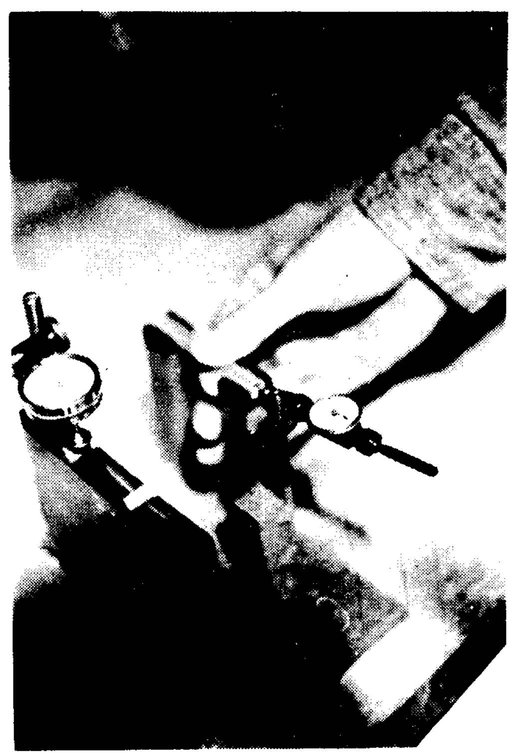
23. and the adjustment of the extrusion machine variables to make tubing.



24. (__1. Maintaining Production) The second major step is the maintaining of production. Maintaining production is the major responsibility of you, the machine operator. This step includes keeping the extrusion machine operating continuously,

25. the cutting, sizing, and bundling of the tubing,

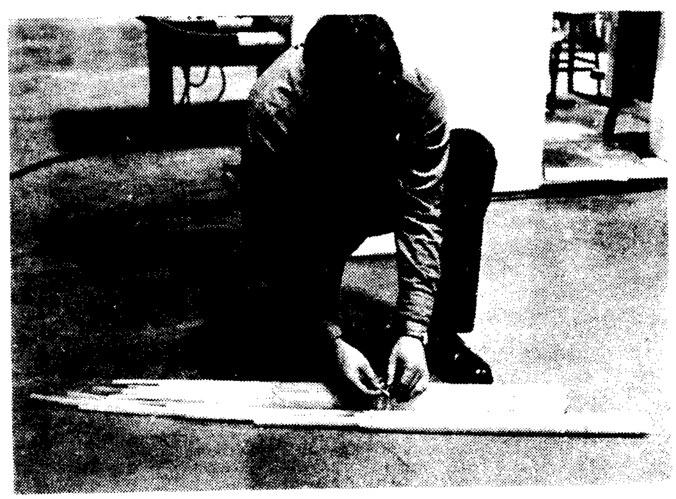
26. maintaining the quality control of the tubing.



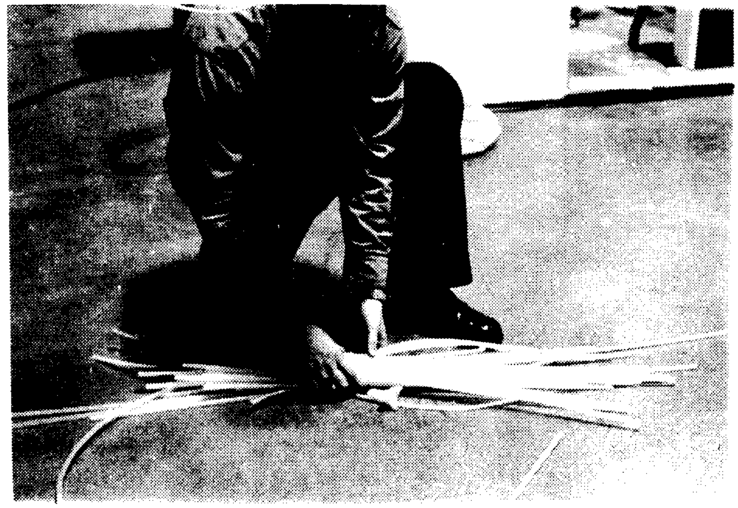
27. and finally, the troubleshooting and correcting of any problem involving the extrusion machine.

28. (__3. Shutting-Down Production)
The last major step involves the shutting-down of the job. This is the easiest of all the major job taks and involves little time. The job tasks include shutting down the extrusion machine,

29. final bundling of the tubing,

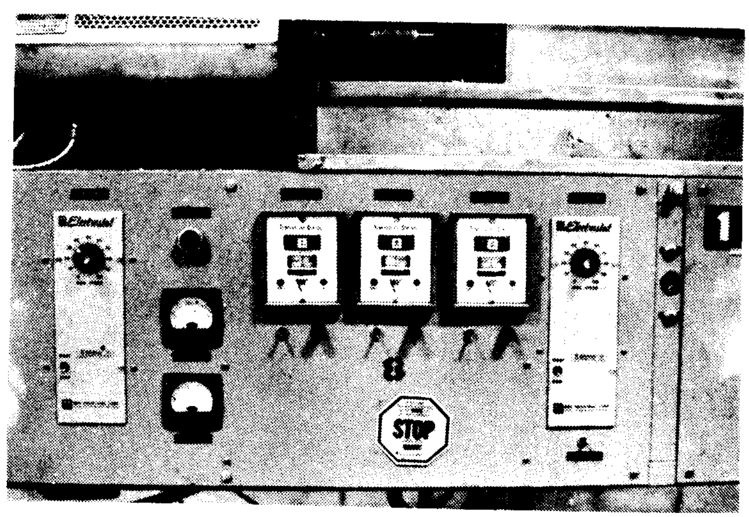


30. putting away tools and equipment,

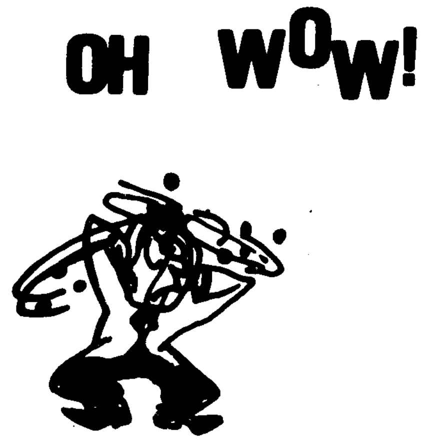


31. housekeeping or cleaning of the work area,

32. and a final check to be sure all extruder switches and valves are turned off.



33. You are now ready to begin specific extruder training. We hope you are not to confused with the information you have been given. If you take each step training one-at-a-time, the job will come easily.

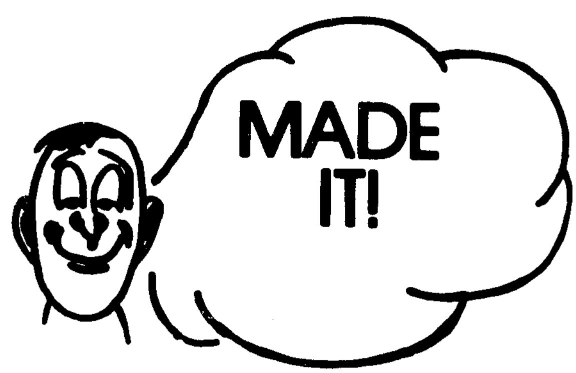


34. Remember your manual has the information you need, when you need it, and it should always be at your fingertips.

35. Your trainer will now take over and instruct you on the specific job tasks. His assistance will make your job easier to perform.

36. Push the stop button on the recorder and call your trainer over to complete the rest of your training.
If you want, you may rewind the tape to review this material. If you have further questions talk to your trainer.

REVIEW



APPENDIX I

Trainee Manual

(Table of contents on the following page. For specific contents refer to Appendix H).

PLASTIC EXTRUDER OPERATOR

Trainee Manual

APPENDIX J

SELECTION OF THE TRAINEE SUBJECTS

Classification of Available Persons	General Characterizations
University Non-academic Personnel (Grounds and Maintenance)	Older, Sincere, Low Achiever
Employment Agency	Low Achiever, Unreliable, Mercenary
B.G.S.U. University Student	Bright, Intelligent, Low Motivation, Mercenary
County and State Maintenance and Road Personnel	Older, Sincere, Low Achiever
Farm Worker	Non-Communicative, Lower Social Class, Unreliable
Farm Owner	Independent, Diligent, Conservative
High School Non-Vocational Non-College	Immature, No Set Goals, Mercenary

Note: Once the worker profile is solidified, subjects (trainees) will be selected from the above categories and evenly divided into the two training groups (structured and unstructured). A pretest will be given and statistically compared to provide additional evidence as to the equality of the two groups.

APPENDIX K

Recruitment Tools

Newspaper Advertisement

PART time work avail. Am doing reserch study. No exp. necessary. Apply at Room 125 A Technology Bldg. BGSU on Wed. July 31, Fri. Aug. 2 or Sat., Aug. 3, 9 a.m.-11:30 a.m. or 1 p.m.-4:30 p.m. or call 372-2002 on these days only.

Ad placed in
Bowling Green Sentinel-Tribune
July 27-31, 1974

Ohio Bureau of Employment Services
(Employment Agency)

JOB BANK REFERRAL (Applicant Introduction to Employer)

1. ORDER NUMBER	2. TYPE	3. LOCAL OFFICE	4.-5. STATION-DESK	6. APPLICANT'S NAME (LAST and INITIALS)	7. SOCIAL SECURITY ACCOUNT NUMBER
868258	R	0900	6003	MEISTER L	28952185

[redacted]

14. DATE of REFERRAL	15. APPLICANT'S OCCUPATIONAL CODE
04-12-74	209.58

PERSON TO SEE STEVE SAWZIN

FOR POSITION OF EXPERIMENT SUBJECT

Disadvantaged

National Alliance of Businessmen

DATE and TIME to APPLY 4-12-74

The bearer of this form has been carefully selected to meet your need for an employee. Another form is being mailed which requests a response as to the outcome of your interview. Your prompt reply to that request will help us to better serve your needs.

EMPLOYER'S NAME STEVE SAWZIN

STREET ADDRESS 125A TECHNOLOGY BLDG. B.G.S.U.

CITY BOWLING GREEN STATE OHIO ZIP Code 43402

372-2002 — 1-5 ...

OBES 508.BF (R-8-73) OHIO BUREAU OF EMPLOYMENT SERVICES 2249

PART - TIME WORK

Opportunity to pickup some extra cash for that new putter, baseball tickets, whatever!

* we need part-time workers for 8 hours minimum
* minimum age - 18
* male or female may apply
* work hours arranged:
  days, evenings, week-end?
  this week;next week;
  next month?
* no experience necessary
* guaranteed base pay with incentive
* the job involves operating production equipment that is being tested
* drop by or phone....

CONTACT:
steve sawzin
125a technology bldg.
bowling green
state university
372-2002 (8-5 weekday)

DROP BY:
1pm - 5pm weekdays
9am - 12pm saturdays
6pm - 9pm mon-wed nights

Steve Sawzin 372-2002
Steve Sawzin 372-2002
Steve Sawzin 372-2002
Steve Sawzin 372-2002
Steve Sawzin 372-2002
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Steve Sawzin 372-2002

APPENDIX L

Application Form

Date of Application ____________

Pay ____________

Can Start Work on ____________

industrial testing services

I T S

NAME ______________________________ Soc. Sec. No. ____________
last first middle

Address ______________________________
number and street city state zip code

____
date of birth sex business phone home phone

____
u.s. military service

have you ever operated plastic processing machinery __________ if yes ____________
from to experience

____

other machines operated and how long each ____________

____

physical handicaps if any ____________

EXPERIENCE RECORD (Last Position First) Continue over or on separate sheet. Include U.S. MILITARY SERVICE RECORD

FROM TO	NAME & ADDRESS OF COMPANY & NATURE OF BUSINESS	POSITIONS HELD (INDICATE CHIEF DUTIES)		

EDUCATION CIRCLE HIGHEST GRADE COMPLETE 1 2 3 4 5 6 7 8 9 10 11 12

NAME OF SCHOOL	ADDRESS	YEARS	COURSE & MAJOR	Yr.Grad	DEGREE
HIGH SCHOOL					
COLLEGE					
BUSINESS					
OTHER					

AFFIDAVIT: I certify that the answers given by me to the foregoing questions and statements are true and correct to the best of my knowledge. I render this university, department, or any person not liable for personal injury that is a result of my negligence or failure to follow given information or warnings.

Signature ____________ Date ____________

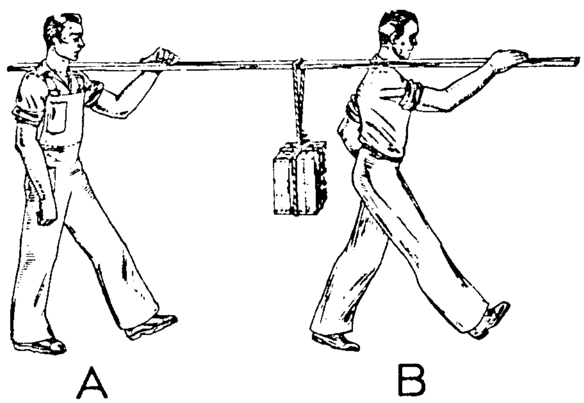
APPENDIX M

Bennett Mechanical Comprehension Test[1]

DIRECTIONS

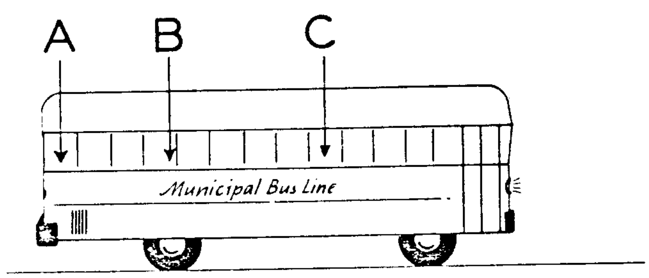
Fill in the requested information on your ANSWER SHEET.

Look at Sample X on this page. It shows two men carrying a weighted object on a plank, and it asks, "Which man carries more weight?" Because the object is closer to man "B" than to man "A," man "B" is shouldering more weight; so blacken the circle under "B" on your answer sheet. Now look at Sample Y and answer it yourself. Fill in the circle under the correct answer on your answer sheet.



X

Which man carries more weight? (If equal, mark C.)



Y

Which letter shows the seat where a passenger will get the smoothest ride?

On the following pages there are more pictures and questions. Read each question carefully, look at the picture, and fill in the circle under the best answer on the answer sheet. Make sure that your marks are heavy and black. Erase completely any answer you wish to change. Do not make any marks in this booklet.

DO NOT TURN OVER THE BOOKLET UNTIL YOU ARE TOLD TO DO SO.

70-158TB

Printed in U.S.A. The Psychological Corporation, 304 East 45th Street, New York, N. Y. 10017

[1]Test contains 68 items. Directions and sample item presented here.

APPENDIX N

TWO TAIL "t" TEST OF SIGNIFICANCE BETWEEN MEANS OF TRAINEE PRE-MEASURES FOR STRUCTURED AND UNSTRUCTURED TRAINING GROUPS

Trainee Bennet Mechanical Comprehension Test Scores

Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	891.00	44.55	41659
Structured	20	901.00	45.05	42575

df = 38 t = .0033 ($p > .9$)

Age of Trainees in Years

Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	556	27.8	18250.0
Structured	20	495	24.75	13012.0

df = 38 t = .3362 ($p < .8$)

Number of Completed Years of Formal Education By the Trainee

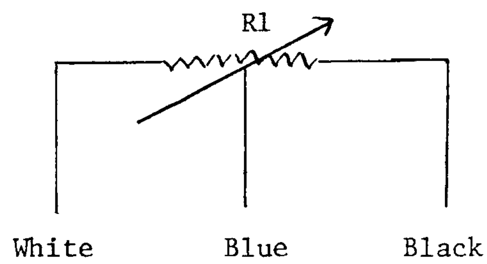
Group	N	ΣX	$\bar{x}$	ΣX^2
Unstructured	20	289	14.45	4229
Structured	20	308	15.40	4834

df = 38 t = .1946 ($p > .9$)

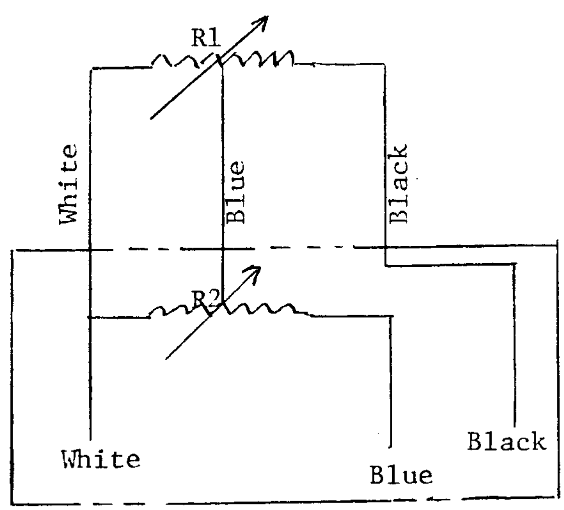
APPENDIX O

Plastic Extruder Remote Control Device

Wiring Diagram

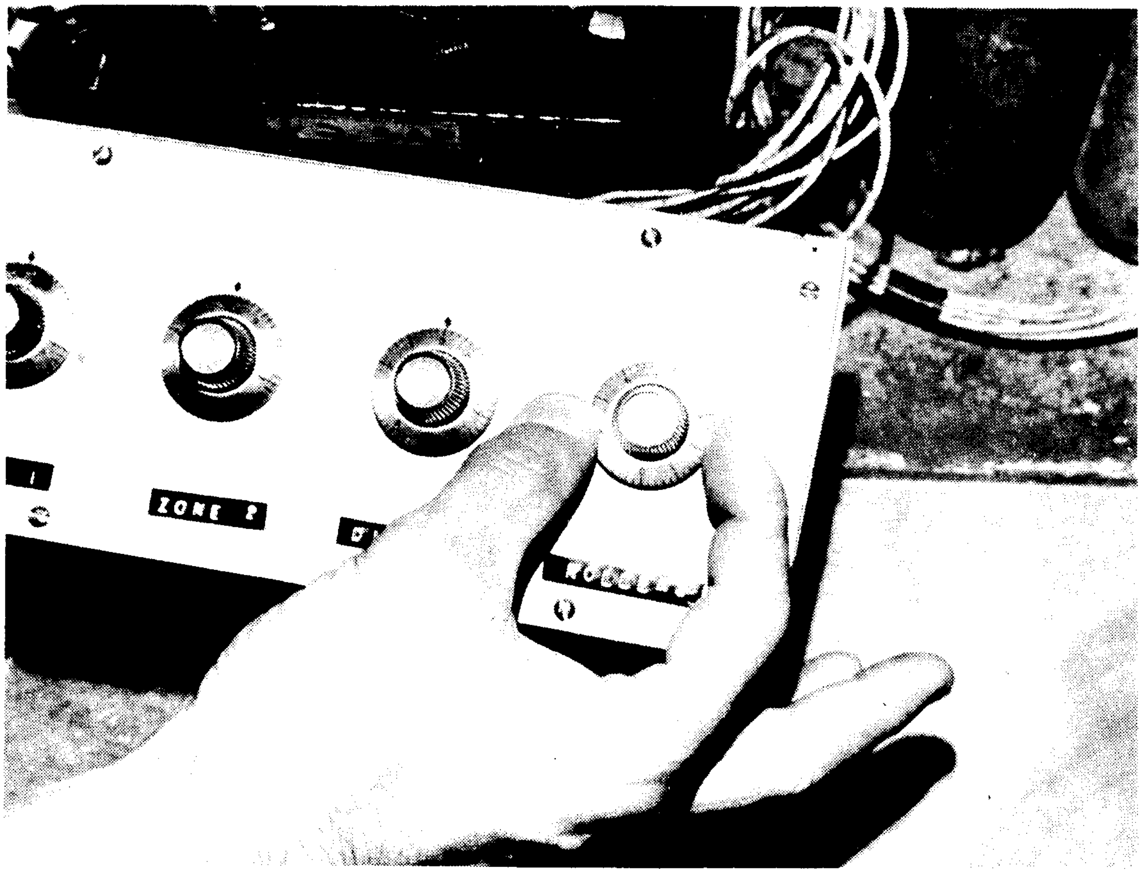


Existing Controller Wiring Diagram



Auxilary Controller Wiring Diagram

R1--Existing Potentiometer
R2--Auxilary Potentiometer
NOTE: The auxilary controls are potentiometers of 5K ohm resistence



This device is designed to inject problems into the plastic extruder. This is achieved by adjusting the extruder controls from a remote location. The objective of the device is to either increase or decrease an extruder variable by the research assistant with the trainee being able to readjust the extruder variable at the extruder, resulting in correction of the malfunction. This device operates electronically in conjunction with the extruder controls.

The design of the device was a joint effort of the research assistant, two undergraduate students in EPIC 191 (Department of Industrial Education and Technology, BGSU) and their instructor, Mr. Anthony

Palumbo. The students performed necessary research and testing of various circuit designs with the help of their instructor. The research assistant designed the malfunction device hardware and wired the device to the plastic extruder utilizing the circuit wiring diagram furnished by students Dave Beers and Gerald McCullough.

APPENDIX P

Worker Attitude Inventory

INDUSTRIAL TESTING SERVICE

Please give us your opinions concerning your experience in operating the pipe extruder. There are no right or wrong answers except how you feel.

Mark SA....If you strongly agree with the item
Mark A.....If you agree with the item
Mark D.....If you disagree with the item
Mark SD....If you strongly disagree with the item

	SA	A	D	SD	
1.	0	0	0	0	The extruding machine is well made
2.	0	0	0	0	Learing to run the extruder was easy
3.	0	0	0	0	I always understood what was going on
4.	0	0	0	0	I would like to be an extruder operator
5.	0	0	0	0	Operating an extruder is an interesting job
6.	0	0	0	0	I always knew why I had to do things.
7.	0	0	0	0	I always understood what the person who was training me was saying or doing.
8.	0	0	0	0	I'd teach someone to run the extruder just the way I was taught.
9.	0	0	0	0	The person who trained me cared about me
10.	0	0	0	0	The extruding machine works well

INDUSTRIAL TESTING SERVICE

Please give us your opinions concerning your experience in operating the pipe extruder. There are no right or wrong answers except how you feel.

Mark SA....If you strongly agree with the item
Mark A.....If you agree with the item
Mark D.....If you disagree with the item
Mark SD....If you strongly disagree with the item

	SA	A	D	SD	
11.	0	0	0	0	The extruding machine is poorly made
12.	0	0	0	0	Learning to run the extruder was hard
13.	0	0	0	0	I never understood what was going on
14.	0	0	0	0	I would not like to be an extruder operator
15.	0	0	0	0	The person who trained me didn't care about me
16.	0	0	0	0	The extruding machine doesn't work well
17.	0	0	0	0	I never understood what the person who was training me was saying or doing
18.	0	0	0	0	I wouldn't teach someone to run the extruder the way I was taught.
19.	0	0	0	0	Operating an extruder is a boring job
20.	0	0	0	0	I never knew why I had to do things

APPENDIX Q

TRAINER CHARACTERIZATION

The trainer is responsible for training new employees entering his department. The trainer monitors, manages, and instructs the trainee with the use of structured training procedures. The trainer is an individual that has been presently working with the company and that department. His responsibilities include working as a production employee and also as the department trainer. To be selected as the department trainer he has exhibited the following characteristics.

A. A positive attitude toward the department, his job, and toward the company.
B. A desire to have the new employee learn the best way to do the job.
C. A desire to teach.
D. Effective communication skills--being able to get across an idea in terms that the other person can understand.
E. Practical knowledge and skill of teaching principles and techniques.
F. Patience.
G. Willingness to prepare to teach.
H. Time to teach.
I. A warm friendly attitude toward the learner. (Vernon, 1972, p. 73)

STAGES OF STRUCTURED JOB TRAINING

Trainee Introduction:

1. The trainer personally orientates the new worker to his job environment and fellow workers.

2. Trainee expectations in the way of performance, work breaks, and work attitudes are presented by the trainer.

Initial Training Period:

1. Trainer is responsible for all training.
2. Trainer is constantly training and interacting with the trainee
3. All information concerning job responsibilities and duties are presented by the trainer.
4. Trainer constantly monitors the progress of the trainee.
5. Trainee fully depends on the trainer or the training instructional material to guide him.

Advanced Training Period:

1. Trainee shows increaded performance
2. Trainer is not needed to stay with the trainee
3. Trainer may leave trainee extensively, depending on the training progress
4. The trainee does not completely depend on the trainer
5. Trainee shows self assurance and confidence on the job.

Progress During Structured Training

The trainer is aware of the trainee's progress at all times. Training schedules, with feedback from the trainee's performance, indicate the progress of the training. The trainee is made aware of his progress versus the training schedule.

Training on Schedule:

1. Trainer indicates to the trainee that his progress is on schedule.
2. Trainer makes no changes in training strategy.
3. Trainer compliments trainee on his improvements.
4. The trainer builds up the trainee's self-confidence.

Training Ahead of Schedule:

1. Trainer shows acknowledgement and encouragement regarding the trainee's performance.
2. Trainer encourages increased good performance of the trainee.
3. Trainer builds on the trainee's self-confidence.

Training Behind Schedule:

1. Trainer is concerned for lack of progress in training.
2. Trainee is made aware of training schedule.
3. Trainer tries alternate strategies of instructing the trainee.
4. Trainer discusses with the trainee how his performance can be improved.

PRODUCTION OUTCOMES FROM STRUCTURED TRAINING

DEFINITION: Production Crisis

1. Production consistantly curtailed because of worker inability to start-up pipe production or keep production rate up.
2. Failure of extruder to operate correctly or its related components.
3. Trainer can determine the degree of crisis by either frantic or rational actions on the part of the trainee.
4. Failure between the trainee and trainer to interact together and communicate thus resulting in loss of production or damage to equipment.

Production Crisis Situation (Neither trainer nor trainee fault):

1. Trainer involved extensively, in troubleshooting, in early training period.
2. Trainer not involved or watches the trainee troubleshoot problems in the advanced training period.
3. Trainer calmly offers suggestions and encouragement to the trainee.
4. Trainee performs all troubleshooting procedures.
5. The trainer involves himself with the equipment only if the trainee's performance fails to correct machine malfunctions (advanced training period.)

Production Crisis Situation (trainee fault):

1. Trainer relies on training materials for instruction to the trainee.
2. Trainer help trainee by giving advice only if trainee cannot perform.
3. Trainer may reinstruct the trainee if needed.

Normal Production (no problems):

1. Trainer has little interaction with trainee.
2. Trainer may leave the work area.

Normal Production (problems):

1. Trainee relies on help from instructional materials.
2. Trainer interaction depends on the stage in the training sequence.

REFERENCE

Vernon, I. R. (Ed.) First-line management: The foreman's role in manufacturing. Dearborn, Mich.: Donald L. Kirkpatrick, 1972.

APPENDIX R

Unstructured Training Program Operational Procedure

The following is a description of the procedures utilized to simulate the unstructured training program in an industrial setting.

The new worker (trainee) is brought on the job by the foreman (researcher) and introduced to the worker-trainer. The foreman leaves the trainee at the job and the training is now the responsibility of the worker-trainer. The worker-trainer and trainee are together for training purposes. During this time the worker-trainer is expected to train the trainee given whatever method is at his disposal. At the second hour of the trainee's employment, a malfunction is injected into the extruder by the researcher to expose the trainee to trouble-shooting malfunctions or production problems. In the third hour the trainer is pulled off the job and the trainee is forced to maintain production alone. If the trainee cannot maintain production various results may occur:

a. the worker-trainer or foreman will return to the job on their own

b. the worker-trainer or foreman will be called to the job by the trainee

c. the worker-trainer will be told to return to the job by the foreman

This action results in a resumption of production. The action is repeated until the trainee can maintain production.

If the trainee can maintain production for thirty (30) minutes a malfunction of the extruder's roller speed is injected. The trainee is faced with three alternatives. If the trainee observes the malfunction, the trainee may:

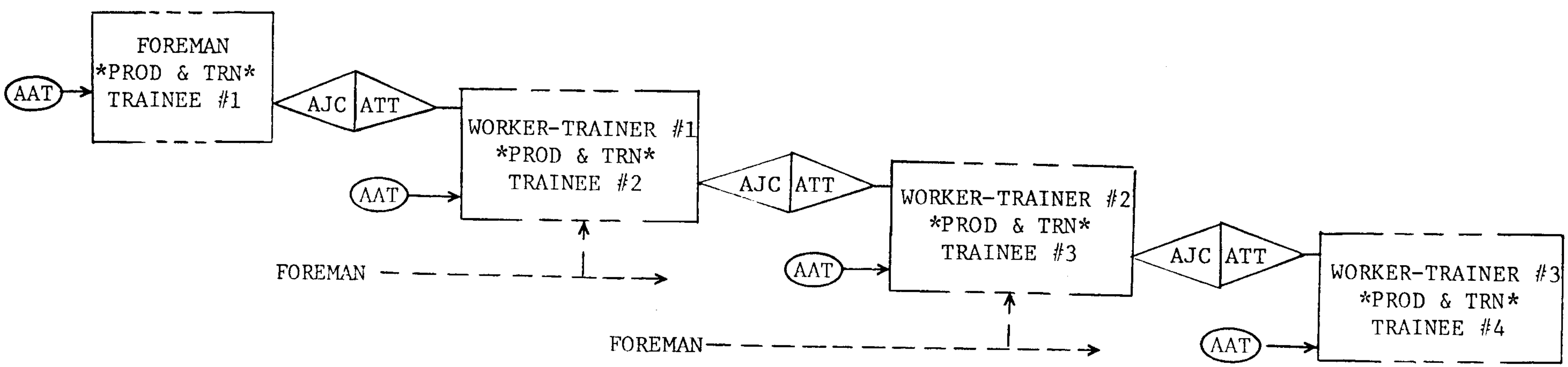
a. let the extruder operate as it is and take no action

b. call in the worker-trainer or foreman to correct the malfunction

c. correct the malfunction

If the trainee observes and corrects the malfunction with no outside help, as well as maintain production for the remaining hour, the trainee will have passed the first production problem test. When the malfunction has been corrected the worker-trainer is put back on the job at the end of the hour. The worker-trainer is taken off the job each time a malfunction is injected until the trainee becomes competent.

UNSTRUCTURED TRAINING EVENTS



AAT — Aptitude and Achievement Test

ATT — Attitudes Toward Training

AJC — Achieves Job Competency

Varied Training Time

Foreman and/or Worker-Trainer Intervention on "Crisis" Events; Generally Foreman is Busy and Preoccupied; Worker-Trainer Busy but Available.

PROD & TRN — Production and Training

Structured Training Program Operational Procedures

The trainee is introduced to the job and the trainer by the foreman or the supervisor. The trainer procedes to introduce the trainee to the work area, the equipment, and fellow workers. Once completed the trainer and trainee procede to the training room for the training introduction and an overview of the job. Once the classroom program for the introduction is completed the trainee and trainer return to the work area. The trainer completes the introduction and job stages one and two, "talking phase." It is important to note that during this phase, either at the work area or in the training room, production is not impeded.

The "talking phase" consists of the trainer explaining all job tasks and trouble-shooting procedures verbally according to the task check sheets and trainer manual. The trainee responds to the trainer by talking through the job tasks and answering questions about the job procedures to the satisfaction of the trainer. This is a form of formative evaluation. This procedure may help the trainer determine the capabilities of the trainee to grasp the job tasks and determine if the trainee is suited for the job. This method also enlightens the trainee to the job and expected performance. The trainee can decide if he or she is capable of performing the job.

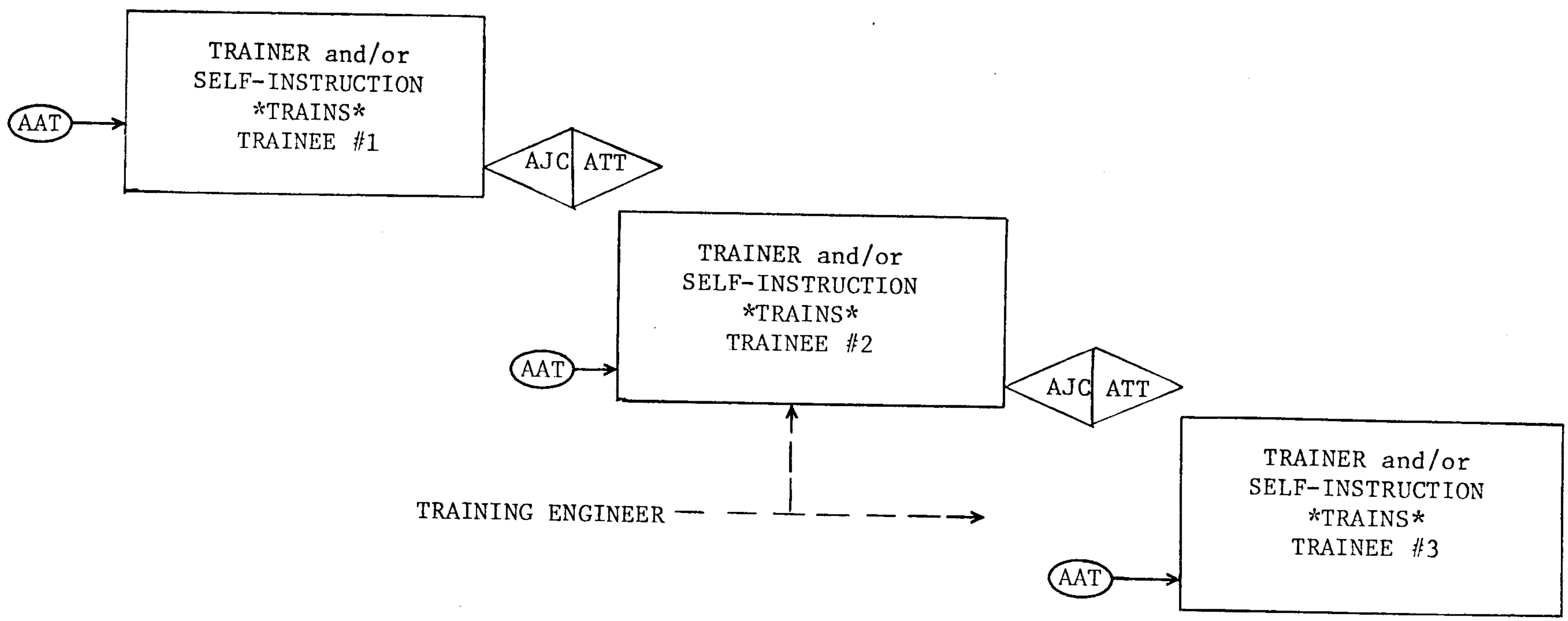
The trainee and trainer return to the training room for specific job instruction of job tasks three through seven and specific production problem training, "talking phase." During this time formative evaluation in the form of verbal and short answer written quizzing is conducted.

When the trainer is confident of the trainee's knowledge of the job, the trainee and trainer return to the work area for specific job instruction and production problem training, "doing phase." At this time, production is impeded because the production equipment is now utilized for training purposes. Production lost is equivalent to production output during training decucted from the standard production rate. The trainee performs all the job tasks with the trainer present. The trainer may demonstrate some job tasks. The trainer closely observes the trainee and helps only if needed. The trainer will head-off any potential problems that will frustrate the trainee's learning and will instruct the trainee about those problems.

When the trainer is confident that the trainee can perform all job tasks the production problem training "doing phase" is conducted. While the trainee is operating the plastic extruder and maintaining production the trainer adjusts an extruder control at the work area causing a malfunction. The trainee must find the malfunction and correct the problem as well as maintain production. When the trainee has solved two malfunctions, answered questions by the trainer, can start-up, maintain and shut-down production, is self confident in performing the job tasks, and the trainer is satisfied in the trainees performance, then the trainee is considered competent in the job.

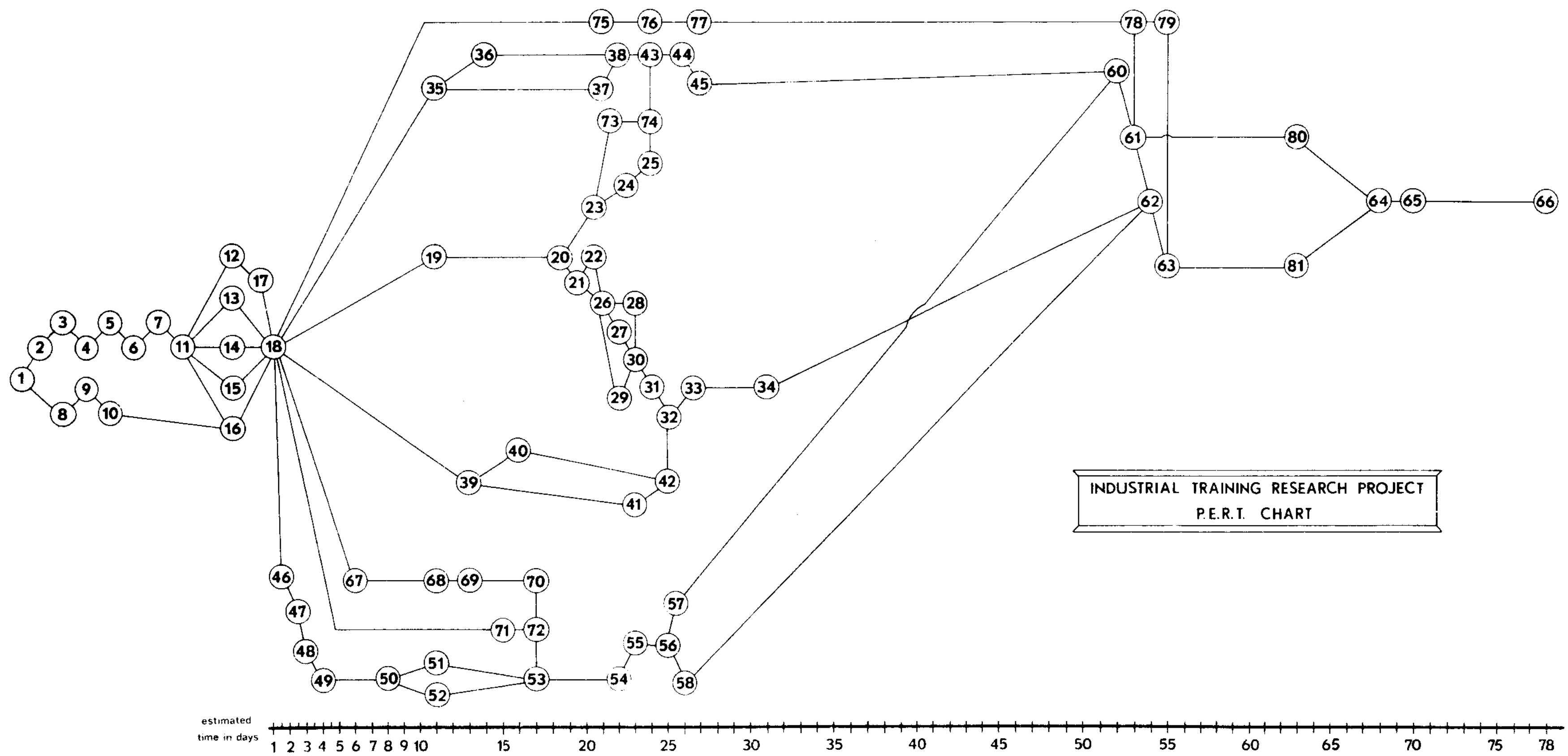
The final test of the trainee's competence is in a performance test unknown to the trainee. The trainee is placed on the job alone. The trainee must start-up and maintain production. The trainee must pass two malfunction tests and maintain the production rate. The malfunctions are injected into the extruder from a remote station by the researcher.

STRUCTURED TRAINING EVENTS



The malfunction injected was an increase or decrease of the take-up roller speed. The trainee is unaware that the malfunctions are purposefully injected.

Additional training is administered only if necessary. The trainee may ask for additional information or information forgotten during training. In a crisis situation the trainee may call in the trainer or solve the crisis alone. The trainer will provide additional training based on the trainee's performance.


INDUSTRIAL TRAINING RESEARCH PROJECT
P.E.R.T. CHART
estimated time in days

1. Start
2. Advertise for Graduate Research Assistant
3. Interview possible Research Assistant
4. Select Research Assistant
5. Research director and assistant conference to discuss potential faculty advisors
6. Contact potential faculty advisors
7. Acceptance by faculty advisors
8. Obtain Rainville Pipe Extrusion information
9. Obtain Rainville Pipe Extrusion equipment
10. Familiarization with operation of extrusion equipment
11. BGSU Research staff orientation; review and revision of draft materials
12. First draft of worker profile
13. First draft of unstructured training Methodology
14. First draft of structured training Methodology
15. First draft of experimental procedures and evaluation
16. First draft of selected production activity
17. Conference with J-M personnel man to review and refine worker profile; second draft
18. Progress report number one
19. Obtain appropriate extrusion material for extruding pipe
20. Specify the effects of extruder variables on the quality and production of pipe
21. Extrusion task listing
22. Extrusion task detailing
23. Pipe production criteria
24. Development of pipe quality control evaluating device
25. Validation of evaluating device

26. Structured training instructional decisions
27. Script
28. Visuals
29. Mock-ups
30. Critique of structured training program
31. Revise structured training program
32. Pilot structured training program
33. Revise structured training program
34. Produce final structured training program
35. Characterization of the production foreman behavior in the unstructured training program
36. Director's critique of 35
37. J-M staff critique of 35
38. Finalization of 35
39. Characterization of the trainer's behavior in the structured training program
40. Director's critique and revision of 39
41. J-M staff critique of 39
42. Finalization of 39
43. Pilot unstructured training program
44. Revise and finalization of unstructured training program
45. Final check of unstructured training program
46. Determine media to use for advertising
47. Develop advertising materials for trainee personnel recruitment
48. Critique and finalize total trainee procurement procedures
49. Place advertisement in selected media
50. Prospective trainees answer advertisement

51. Telephone appointments for job interview by applicant
52. Walk-in applicant for job interview
53. Fifty applicants fill out application and take pretest
54. Applicant interview
55. Accept/reject applicant
56. Randomly divide accepted applicants into two groups
57. Unstructured training group
58. Structured training group
59. Perform unstructured training program
60. Collect unstructured training data
61. Perform structured training program
62. Collect structured training data
63. Comparison and analysis data from the two training groups
64. Outline final report
65. Write final report
66. Obtain J-M application form from J-M Defiance
67. Modify and develop form for research use
68. Application format; advisor approval
69. Duplicate copies of application form
70. Obtain sample pre-test aptitude tests
71. Select pre-test aptitude test
72. Specify extruder operation performance test samples
73. Develop and validate extruder operation performance test
74. Develop a cost effectiveness model for industrial training
75. Critique and revise cost-effectiveness model
76. J-M staff critique of 75

APPENDIX S

Summary of Raw Data

FINAL DATA SUMMARY

		Unstructured	Structured	T Score	Probability Confidence Level
	TOTALS				
1.	Total Training Hours	326.00	91.00		
2.	Total Training Production	12745.0	3386.00		
3.	Total Training Production Loss in Pounds	187.03	58.20		
4.	Total Training Waste in Pounds	440.64	105.81		
5.	Total Training Production in Pounds	636.86	169.30		
	$\bar{x}$ PER TRAINEE				
1A.	$\bar{x}$ Training Hours Per Trainee	16.3	4.55	2.8609	$p < .01$
2A.	$\bar{x}$ Training Production Per Trainee	637.25	169.30	3.80	$p < .001$
3A.	$\bar{x}$ Training Production Loss in Pounds Per Trainee	9.35	2.91	3.01	$p < .01$
4A.	$\bar{x}$ Training Waste in Pounds Per Trainee	22.03	5.29	3.9481	$p < .001$
5A.	$\bar{x}$ Training Production in Pounds Per Trainee	31.84	8.46	3.7973	$p < .001$
	$\bar{x}$ PER TRAINING HOUR				
1B.	N/A				
2B.	$\bar{x}$ Training Production Per Training Hour	39.71	37.65	0.1624	$p > .8$
3B.	$\bar{x}$ Training Production Loss in Pounds Per Tr. Hour	0.54	0.61	0.338	$p > .7$
4B.	$\bar{x}$ Training Waste in Pounds Per Training Hour	1.39	1.29	0.2127	$p > .8$
5B.	$\bar{x}$ Training Production in Pounds Per Training Hour	1.98	1.88	0.1587	$p > .8$
6	$\bar{x}$ Posttest Score	51.95	58.35	-.3541	$p > .7$

TRAINING COSTS

STRUCTURED TRAINING		Structured Training Totals	Unstructured Training Totals	UNSTRUCTURED TRAINING	
1. TRAINING DEVELOPMENT		338.00	0		
Trainer--56 hrs. @ $11,000 yr. salary	308.00				
Secretary--32 hrs. @ $5,000 yr. salary	80.00				
2. TRAINING MATERIALS		21.76	0		
Folder-Trainer Manual	0.30				
Folder-Trainee Manual	0.30				
Folder-Introduction Overview Script	0.30				
Paper-Typed Pages	3.00				
Cassette Audio Tape	0.75				
Training Photographs Introduction Overview	9.00				
Poster Board for Training Aids	2.25				
Poster Paper for Training Aids	0.90				
Press-type Letters for Training Aids	4.96				
3. REPRODUCTION--QUANTITY OF 20		50.80	0		
Manual Folders	6.00				
Paper for Manuals	24.80				
Secretary Duplicating Manuals	10.00				
Secretary Collating & Binding	10.00				
4. TRAINING TIME		601.00	901.99	TRAINING TIME	
Trainee Time	227.50			Trainee Time	815.00
Trainer Time	360.00			Trainer Time	0
Trainer Crisis Time	13.50			Foreman Crisis Time	86.99

TRAINING COSTS -- Continued

STRUCTURED TRAINING		Structured Training Totals	Unstructured Training Totals	UNSTRUCTURED TRAINING	
5. PRODUCTION LOSSES		63.47	242.91		
Production Rate--Loss in Pounds of Product	22.52			Production Rate--Loss in Pounds of Product	72.38
Production Material Waste in Pounds of Plastic	40.95			Production Material Waste in Pounds of Plastic	170.53
TOTALS		1125.03	1144.90		
Average Cost per Trainee		56.25	57.25		
Total Development Training Costs Σ 1 and 2		409.76	0		
Average Training Development Cost per Trainee		20.49	0		
Total Training Delivery Costs Σ 3,4,& 5		715.27	1144.90		
Average Training Delivery Cost Per Trainee		35.76	57.25		